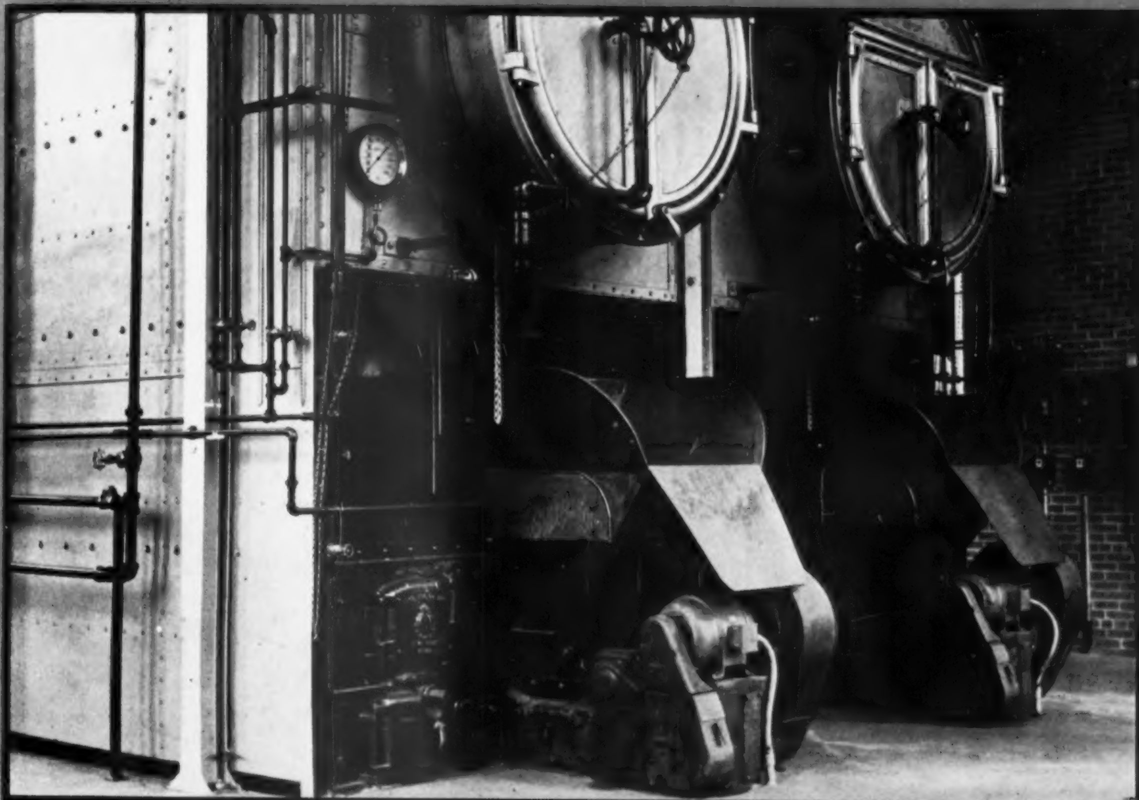
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

September, 1945



Small stoker fired installation in the South

Power Plant of the Volta Redonda Steel Mill in Brazil ▶

Electric Power Situation in Italy ▶

Structural Changes in Carbon and Molybdenum Steels During Prolonged Heating at 900 - 1000 F ▶

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Contents

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Feature Articles

Editorials

Departments

ALFRED D. BLAKE, *Editor* — THOMAS E. HANLEY, *Circulation Manager*

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Editorial

Conventions Get the Green Light

Along with the lifting of numerous governmental wartime restrictions comes an announcement from the Office of Defense Transportation that the ban on conventions, group meetings and trade shows will be lifted entirely on October first. At the same time it was pointed out that there is no assurance of adequate transportation being available, in view of which it is suggested that large gatherings of national scope be deferred until after the peak in troop movements.

With the modification of the restrictions in August to permit out-of-state attendance up to one hundred fifty persons, many of the engineering societies proceeded to arrange meeting programs on a reduced or regional scale. The latest announcement comes too late to affect most of the scheduled fall meetings, but in time to permit winter and spring meetings to be planned along pre-war lines, with due consideration to the probable transportation inconveniences.

Much can now be discussed at engineering meetings that was previously precluded for security reasons, but the way is open to assess the influence of certain wartime developments on peacetime progress. This is especially true of the engineering field which played such an important rôle in the war effort.

Atomic Energy

With the advent of the atomic bomb speculation became rife as to the possibilities of nuclear energy supplanting present sources of power.

While hastily conceived predictions are worthless, it is equally fallacious to assume a negative attitude with respect to such matters in a world of rapid scientific advancement. It is well to remember, however, that atomic physics is not new; it has been the subject of research in many countries for over forty years and much has been learned as to structure of the atom and its potential energy.

That we were able, through vast expenditure, to apply such forces to development of the atomic bomb, ahead of our enemies, was fortunate; but this does not necessarily mean that the control of such energy for peacetime use is "just around the corner," or that it will prove economically feasible. Authoritative sources at present view the direct conversion of atomic energy into electric power as remote, although some see a possibility of converting it into useful heat. However, much further research and development will be necessary to control the energy release and to cope with the temperatures involved; hence our present modes of power generation are likely to be in effect for many years.

Power Plant of the Volta Redonda Steel Mill in Brazil

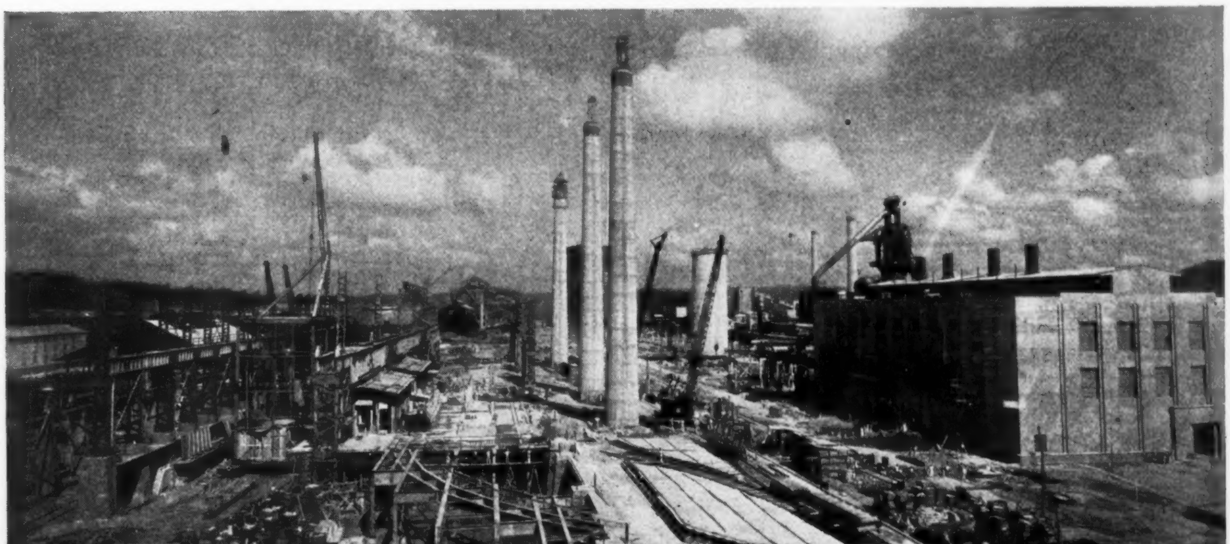
By RALPH D. KIRCHER*

This power plant, consisting of four boilers, two 5000-kw turbine-generators and two 7000-hp turbo-blowers, burns blast-furnace gas, pulverized Brazilian coal and coke-oven gas, when available. It is of sufficient capacity to keep essential parts of the steel plant in operation should failure occur in the purchased power supply which serves as the primary source. The entire steel plant project was engineered by Arthur G. McKee & Company of Cleveland, O., and construction in the field was carried on by the Brazilian National Steel Company's own force under McKee Company supervision.

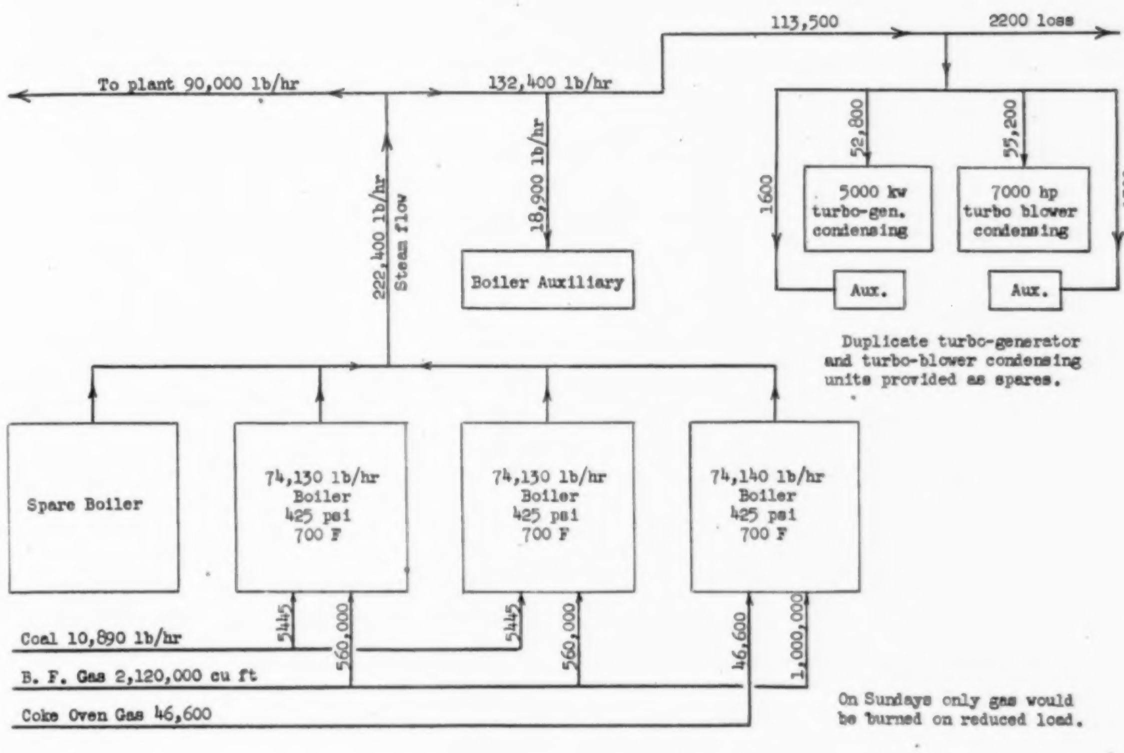
THIS new steel mill at Volta Redonda, Brazil, constructed for the Brazilian National Steel Company (Compania Siderurgica Nacional) is now nearing completion after nearly five years of planning and construction. It is the only modern and completely integrated steel plant in South America. It will utilize native ores, coal, limestone, etc., and its ultimate annual output of 500,000 to 600,000 tons is expected to play an important part in Brazil's industrial economy, as heretofore by far the greater part of the steel utilized in that country was imported.

The site chosen is in the State of Rio de Janeiro, at the turn of Volta Redonda which is about 90 miles north and west of Rio de Janeiro. The plant lies in a valley on one side of which flows the Rio Parayba (a stream about the size of the Kanawha River in West Virginia), and on the

* Formerly with Arthur G. McKee & Co., in charge of power plant design of this project, and at present with H. A. Brassert & Co., consulting engineers.



Construction view of steel plant with power house at right



Fuel- and steam-flow diagram

opposite side are the tracks of the Central Railroad of Brazil. This railroad connects the steel plant with the cities of Rio de Janeiro and São Paulo.

Much of interest could be written about the steel plant, but the purpose of this article is to describe the steam power plant serving the steel works, and which differs in certain respects from conventional industrial power plants or central stations, because of conditions peculiar to steel plant operation.

Unlike a typical central station where fuel economy and thermal efficiency are paramount, a steel mill power plant is usually designed to employ unsalable surplus fuels such as blast-furnace gas and coke breeze. Hence, fuel economy, up to the point of full consumption of the available fuels, is not of utmost importance. On the other hand, reliability of steam generation and continuity of service under adverse operating conditions is a prime necessity.

One of the principal steam consumers is the turbo-blower serving the blast furnaces and this must be kept in service constantly. Moreover, in this instance a duplicate spare condensing turbo-blower is provided.

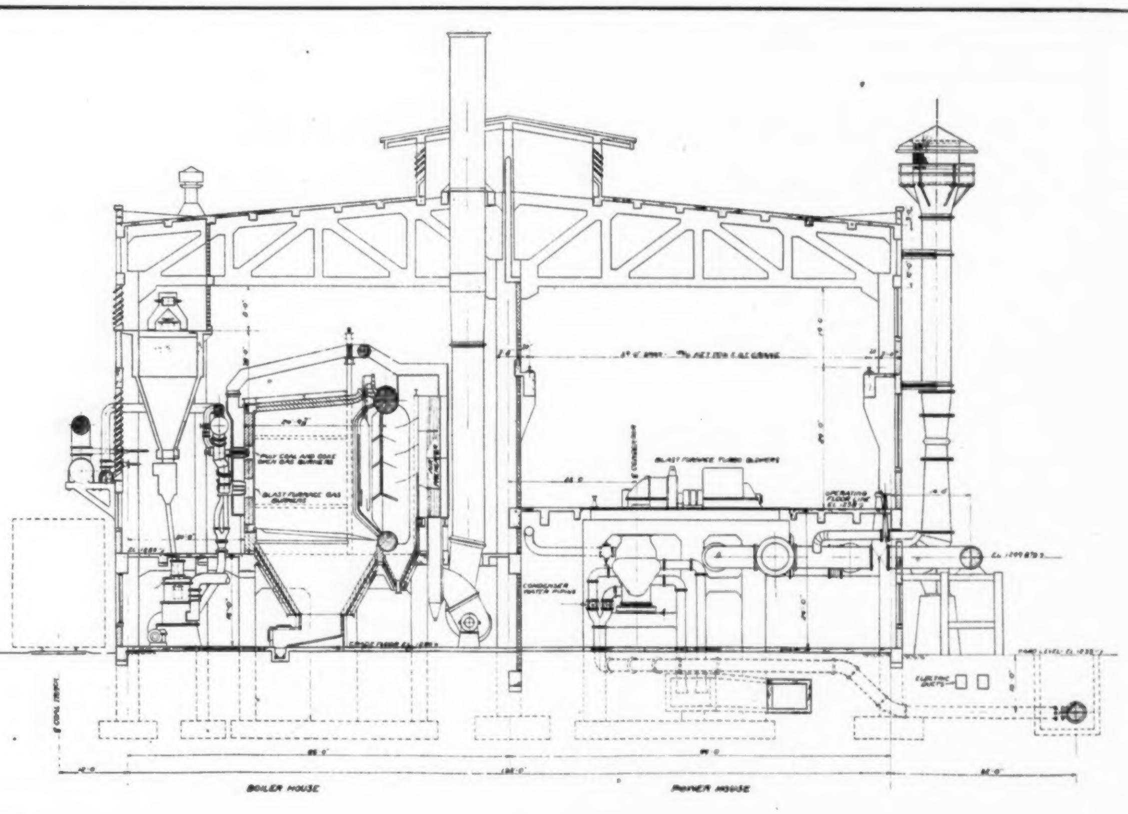
The steel plant proper is electrically driven by power purchased from the Rio de Janeiro Tramway Light & Power Company which operates a hydroelectric plant about 30 miles from the steel mill. This power is furnished at 6600 volts, 3-phase, 50 cycles. Consequently, generation of electric power at the steel mill is confined to the amount necessary to supply such units as must be kept in operation in case of failure of the purchased power. This factor was balanced against the amount of surplus fuel available for steam generation after that required by the turbo-blower was satisfied. With this in mind, a 5000-kw condensing turbine-generator was found sufficient, although a second, similar unit was installed as a reserve. This provides electric generating capacity of 10,000 kw that can be employed to operate the mill at reduced capacity in case of prolonged outage of purchased power.

The steam generating capacity was determined on this basis and four units were selected in order to provide flexibility. Space is available in the boiler room for two additional steam-generating units should future requirements warrant their installation.

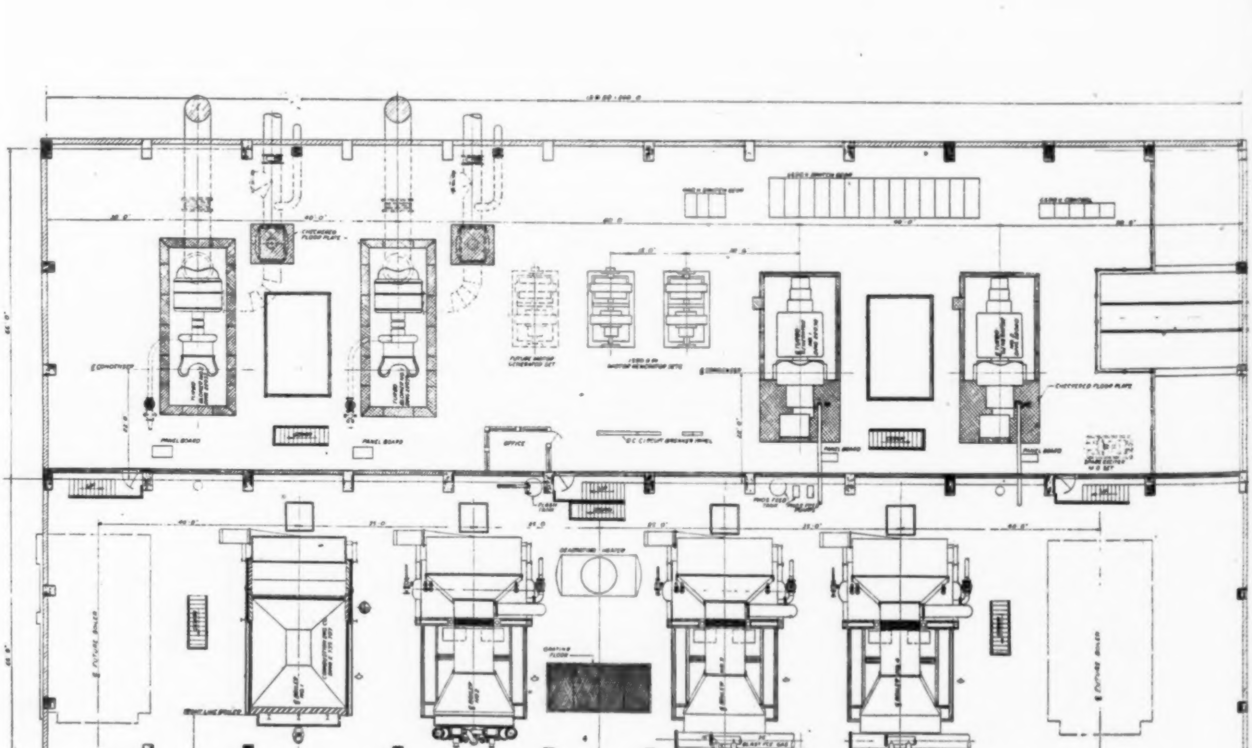
In addition to the main boiler plant at the power house, waste-heat boilers are installed adjacent to the open-hearth furnaces to supply approximately 30,000 lb per hr of low-pressure steam. This, together with the 90,000 lb per hr from the main boilers, at reduced pressure and temperature, supplies the demand for process steam at the coke plant, the rolling mill and the blast furnaces. Process steam in the rolling mill is used for pickling vats and for operating various machines equipped with steam cylinders; also small amounts of steam, together with water, are used for de-scaling the steel. A large amount of low-pressure steam is required in winter for heating, especially in the rolling mills.

A heat-balance study, with reference to the feedwater heating cycle, showed that steam-driven auxiliaries would be more desirable and efficient, in this particular case, than bleeding the main turbines. This is readily accountable by the large quantity of exhaust steam needed by the hot-process water-treating plant and a similar quantity for deaeration in the feedwater heater. In addition to these considerations, it was believed that the reliability of modern mechanical-drive turbines and their simplicity of speed control under adverse operating conditions were important enough factors to give them preference over motor-driven auxiliaries for steel-mill operation.

Only one deaerating feedwater heater was installed, but a large condensate-return storage tank was provided, so that the heater can be bypassed when necessary; and hot



Elevation through power plant



Plan of power plant

water from the treating plant and condensate can be mixed in this tank and fed to the feed pumps. Three boiler feed pumps are provided, two of which will be in normal operation and the third a spare. These are also turbine driven.

To provide supplementary fuel for the blast furnace gas, pulverized coal was chosen rather than using coke breeze. There were two reasons for this. First, it was not deemed desirable to burn blast-furnace gas alone in a furnace provided with a stoker for burning coke-breeze as it was believed the grates might be injured; and second, it was found more desirable to gasify the coke breeze in a gas producer for metallurgical purposes. Consequently, it was decided to use the Brazilian coal in pulverized form as supplementary fuel. Although the ash content is high, the fusion point of the ash is also high and the grindability factor was satisfactory. A typical analysis of this coal is as follows:

Btu per lb (dry)	12,950 to 10,200
Ash, per cent	16 to 32
Sulphur, per cent	1 to $1^1/_2$
Volatile, per cent	47.2 to 39.5
Ash fusion temperature	2850 to 2630 F
Grindability	51 to 55

The blast-furnace gas has a heating value of 92 Btu per cu ft at 60 F and 30 in. Hg, an average dirt content of 0.015 grains per cubic foot and a maximum pressure in the mains of 14 psi. The heating value of the coke-oven gas is 500 Btu per cu ft at 60 F and 30 in. Hg.

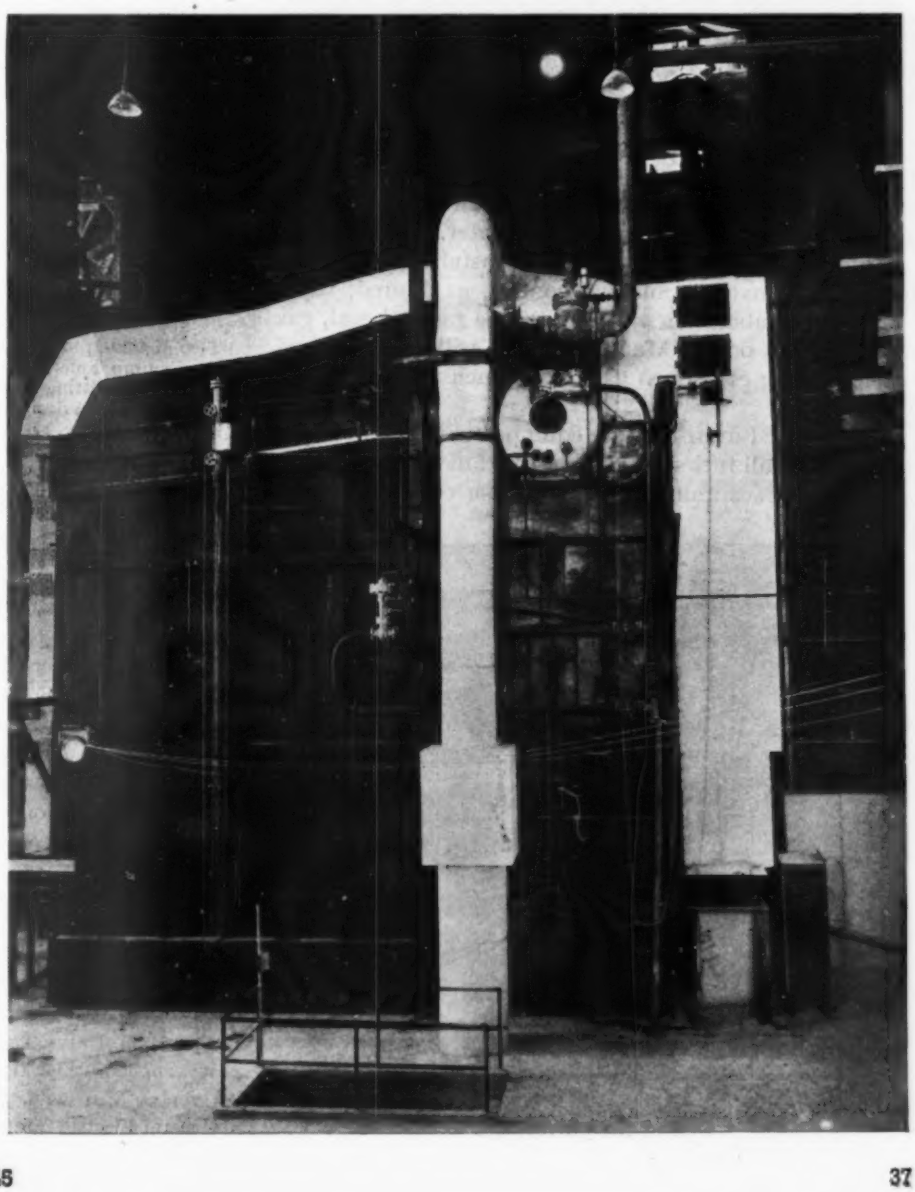
Coke-oven gas will be used only at such times as the steel mills are not operating, in which event the steam load will be reduced.

A 5-million cubic foot gas holder is part of the blast-furnace gas distributing system to maintain a uniform pressure in the mains. In the burning of blast-furnace gas, safety controls are arranged so that when the gas pressure drops to a predetermined minimum the gas supply valve closes and must be reopened manually after the pressure is restored.

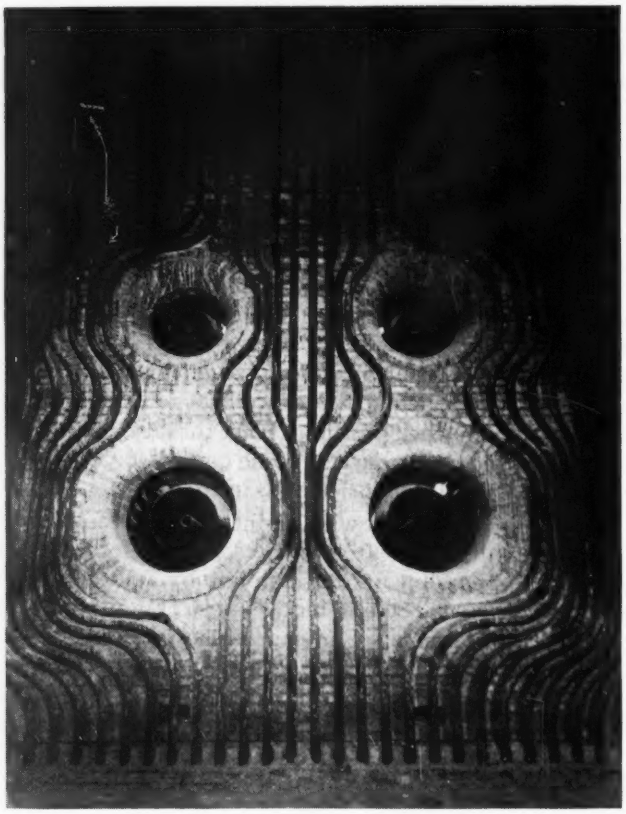
As previously mentioned, four boilers were selected, one serving as a spare. Each is normally rated at 85,000 lb of steam per hour at 425 psi and 665–725 F (depending upon the fuel burned) and 220 F feedwater temperature when burning coal or blast-furnace gas independently; at 75,000 lb per hr when burning these fuels in combination.

The steam-generating units are of the C-E two-drum bent-tube type, provided with refractory-lined hopper bottoms equipped with sluices for handling the ash when burning pulverized coal. The furnaces are completely water cooled with finned tubes on the roof and side walls and plain tubes on the front wall. A water screen extends over the hopper to cool the ash. There are four burners per unit, two of which are of the combination type for burning pulverized coal and coke-oven gas, and two for blast-furnace gas. Each unit is served by a Raymond bowl mill. The calculated furnace heat release is 19,200 Btu per cu ft when burning blast-furnace gas alone, 18,400 Btu when burning coal alone and 16,400 Btu when burning coal and blast-furnace gas in combination.

Each unit is provided with an interbank Elesco superheater, a tubular air heater and a 29,500-cfm forced-draft fan driven through a flexible coupling by a 50-hp steam turbine; also a 92,880-cfm induced-draft fan driven by a 164-hp steam turbine. Fan capacities were selected on the basis of operation at 1230 ft elevation. The fans are located at the rear of the unit on the level below the operating floor and the mills in front of the units, but at



One of the steam-generating units viewed from side



Burners in front wall viewed from furnace

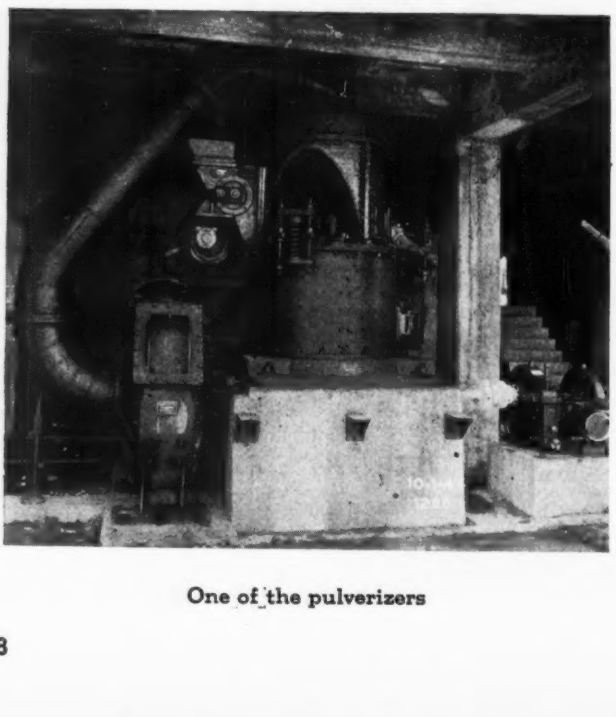
the lower level. Accessories include feedwater regulators of the pilot type, water columns, blowdown valves, gages, and soot blowers for boiler and air heater.

Automatic combustion control is installed to provide for full automatic or manual control, as desired, when burning a combination of blast-furnace gas and coal, gas only, or coal only. Manual control will be employed when burning coke-oven gas, for at such times the load will be low.

The induced-draft fans are equipped with relays which will shut off all fuel supply in case of fan failure. As an additional precaution, the fan turbine control throttle valve is set so that it cannot fully close, which permits the fan to be kept in motion should the control mechanism fail to function. This is a necessary precaution when burning blast-furnace gas or pulverized coal to prevent furnace explosions.

The turbines driving the pulverizers are automatically controlled by the combustion control system; and, in addition, they may be manually controlled from the master panel located on the boiler room operating floor.

As previously stated, plans for the project were initiated nearly five years ago, but construction was retarded by priority restrictions on materials, most of which came from the United States, and by other delays incident to the war. Although the power plant has been ready for some time, operation of all parts of the steel plant must be coordinated before the power plant is placed in regular service, and this has delayed operation beyond the date anticipated.



One of the pulverizers

Principal Equipment

STEAM-GENERATING EQUIPMENT
Furnished by Combustion Engineering Company and including boilers, air preheaters, burners, pulverizers, fans (Buffalo Forge) and all interconnecting piping and ductwork.

COAL HANDLING
Furnished by Robins Conveyors, Inc.

ASH HANDLING
Hydro-Ash Corporation

TURBINE-GENERATORS
Two 5000-kw, 3-phase, 50-cycle, full condensing General Electric units

TURBO-BLOWERS
Two 67,000-cfm, at 20 psi, Ingersoll-Rand units

SURFACE CONDENSERS
8500 sq ft, two-pass Ingersoll-Rand type

CONDENSER CIRCULATING PUMPS
Two 15,000-gpm pumps, working in parallel and located in the river pump house, supply the condensing water for both the electric-generating units and the turbo-blowers. These pumps of Worthington design have a 12-ft suction lift and 58-ft discharge head.

CONDENSATE PUMPS
One turbine-driven and one motor-driven for each condenser, furnished by Ingersoll-Rand.

WATER TREATING PLANT
Hot-process of 20,000 gph capacity furnished by Cochrane Corporation. Although the river water is soft it contains large quantities of silica during flood periods.

BOILER FEED PUMPS
Two 300-gpm Ingersoll-Rand pumps per unit; all turbine driven.

FEEDWATER HEATER
Cochrane deaerating type of 300,000 lb per hr capacity.

DESUPERHEATER AND PRESSURE-REGULATING STATION
Supplied by Swartwout Company

COMBUSTION CONTROL
Hagan type

INSTRUMENTS
Brown Instrument Company

VALVES
Chapman

PIPING
Furnished by Shaw Kendall Company

MECHANICAL DRIVE TURBINES
Westinghouse Electric Corp.

AUXILIARY MOTORS
General Electric Company

The Electric Power Situation in Italy

By Ing. Dott. Giovanni Coppa Zuccari

Rome, Italy

A review of the extent to which the war destroyed power generating capacity in the four geographical regions of Italy, the progress of restoration to date, and the general economic situation as dependent upon an early return to normal power supply.

BECAUSE of the limited available supplies of solid and liquid fuel in the last few years, due to the policy of the Fascist Government, hydroelectric power was highly developed and constituted one of the basic industries of Italy, as shown in the following table taken from a report to the Senate Committee of the Public Works Budget (1942–43).

Plants in Operation in 1941

Type	Number	Capacity
Hydroelectric Power Plants	1171	5,307,000 kw
Steam Power Plants	182	921,600 kw
Geothermic (Lardarello)*	5	80,300 kw

Electric Energy Produced in 1941

Hydroelectric	19,114,500,000 kwhr
By Steam Power Plants	648,000,000 kwhr
Geothermic	650,000,000 kwhr
Imported	232,500,000 kwhr

Distribution of Electric Energy Produced in 1941

Light and Heat	1,858,000,000 kwhr
Electric Traction	2,271,000,000 kwhr
Manufacturing	8,258,000,000 kwhr
Chemical and Metallurgical Industries	8,258,000,000 kwhr

The war, through bombardment and the systematic destruction wrought by the retiring German Army, has so destroyed the electric power supply in Southern and Central Italy, that the actual condition is difficult to evaluate at this time. It is, nevertheless, possible to give some indications as to the serious problems which this industry has to face in the immediate future.

With reference to the requirements of the different industrializations of the various regions of Italy and their relation to the possibility of economic exploitation of water power, the 6,300,000 kw of total installed capacity was apportioned among the four zones into which Italy is logically divided, namely, Insular Italy (Sicily, Sardinia and minor islands), Southern Italy, Central Italy and Northern Italy.

Greatest Destruction in Central Italy

The rapid advance of the Allied Armies in Southern Italy was responsible for there being much less destruction of power facilities in that region than that which took place to such a great extent in Central Italy. While destruction in Southern Italy was limited to about 47 per cent of the installed power, that in Central Italy amounted to approximately 96 per cent of the installed capacity. Consequently, it can be stated that, after the fighting ceased in these two zones, the effective productive capacity was reduced to only about 17 per cent of the total available before the war. In Northern Italy, however, the insurrection of the population permitted salvaging almost all the hydroelectric power plants there located.

These figures give an idea of how serious the destruction of sources of electric energy has been and of the magnitude of this problem now facing the existing Italian Government. The pattern of destruction practiced by the retreating Germans was similar for practically all power stations and this is being carefully studied with a view to expediting restoration of service. Only through miraculous performance by the Italian technicians and operators, will it be possible to restore 50 per cent of the productive capacity in the most seriously damaged zones in the near future. With the very limited means at our disposal it will not be possible to do better, considering the fact that the electric and motor industries are concentrated in Northern Italy and are themselves in need of fuel and raw materials.

The destructions have greatly cut down the use of electric power by the chemical and metallurgical industries; but it is necessary for the tranquility of Italy and Europe that the Italian people go back to work and that all Italian power stations be put back in working condition as soon as possible.

State Control Indicated

With reference to the electrical industry in Italy, a situation was created before and during the war, which must be solved without delay so that the work of reconstruction can start and proceed with efficiency. At the present time the electric power industry is controlled by private agencies closely allied throughout the entire country. Many people are of the opinion that this monopoly, created under certain circumstances and ably exploited, should be replaced by State control of all electric enterprises. This, evidently, will bring about a clash between the private interests and political parties, although ultimate State control seems indicated.

However, the work of reconstruction is proceeding rapidly and by the end of the present year it is hoped to bring the production of electric power in Southern and Central Italy up to about 50 per cent normal, as against the 17 per cent being produced at present. Moreover, during the reconstruction period provisions are being made to unify the voltages and frequencies.

It is evident that the Italian power equipment industry, manufacturing turbines, motors and electrical machinery in general, cannot, for at least a year or more satisfy the Italian demand, so that Italy promises to be a good market for those countries that can supply hydraulic, steam and electric machinery necessary to bring civilian life back to normal.

*Natural steam of volcanic origin exuding through fissures in the earth.

Structural Changes in Carbon and Molybdenum Steels During Prolonged Heating at 900–1000 F

By G. V. SMITH, R. F. MILLER and C. O. TARR

Research Laboratory, U. S. Steel Corp.

The following, which is a condensation of a paper recently prepared for presentation to the American Society for Testing Materials, covers the results of investigations on three carbon and six molybdenum steels at temperatures from 900 to 1100 F over periods ranging up to 5000 hr; each being tested in both annealed and normalized conditions and their hardness and microstructure observed. The rate of spheroidization was greater in the normalized steels, but less marked in the carbon steels. Graphite formed in all the carbon steels, but only in those molybdenum steels to which aluminum had been added.

ENGINEERING structures used for prolonged service at elevated temperatures are usually designed on the basis of creep or stress-rupture data, which are obtained in tests of short duration relative to the service life. These properties depend upon the microstructure of the metal, and inasmuch as metals undergo changes in microstructure when held at elevated temperature, the creep and stress-rupture strengths in reality vary continuously, generally decreasing, throughout the service life.

It is therefore desirable to study the microstructural changes occurring over longer periods at the temperature of interest, or as simulated, though not always equivalently, by shorter tests at higher temperatures. Accordingly, a number of samples, (Table 1) comprised of three carbon (0.1 per cent) steels of similar composition but deoxidized differently, and six molybdenum steels (0.1–0.2 per cent C, 0.5 per cent Mo), similar except for silicon content and mode of deoxidation, were tempered for periods ranging up to 5000 hr at 900, 1000, or 1100 F; and observations were made of hardness, measured at ordinary temperature, and microstructure, particularly with respect to the progress of spheroidization and the possible occurrence of graphite. All but one steel were of commercial manufacture, as commonly used for elevated temperature service, and each was tested in two initial conditions, annealed and normalized.

Initial Heat Treatment

Since commercial practices usually involve air cooling (normalizing) or furnace cooling (annealing) from the

TABLE 1—ANALYSIS AND DEOXIDATION PRACTICE

No. of Steel	Type of Steel	C	Mn	P	S	Si	Cu	Cr	Mo	Ti	Zr	Al	Al_2O	Deixodizers Added* Ladle, Lb/Ton	Deixodizers Added* Mold, Lb Al/Ton	After Carburizing Test A.S.T.M. Grain Size	Structural Normality
1	Mo	0.16	0.82	0.020	0.027	0.47	0.02	0.03	0.48	...	..	0.039	0.009	0.9 FeMn 12.6 FeSi	1.0	6–8	Moderately abnormal
2	Mo	0.16	0.84	0.019	0.030	0.47	0.03	0.03	0.47	...	..	0.006	0.003	0.9 FeMn 12.6 FeSi	0.0	2–4	Slightly abnormal
3	Mo	0.20	0.84	0.026	0.026	0.22	0.02	0.02	0.48	...	..	0.005	0.006	0.9 FeMn 7.7 FeSi	0.0	2–3	Slightly abnormal
4	Mo	0.21	0.85	0.024	0.026	0.23	0.03	0.01	0.48	...	..	0.035	0.005	0.9 FeMn 7.7 FeSi	1.5	6–8	Moderately abnormal
5	Mo	0.20	0.73	0.031	0.031	0.23	0.04	0.24	0.51	...	0.04	0.004	0.004	5.1 FeSiZr	0.0	2–4	Normal
6	Mo	0.11	0.46	0.009	0.012	0.02	..	0.17	0.43	...	..	0.084	0.009	0.0 FeSi	3.0	7–8	Moderately abnormal
7	C	0.13	0.45	0.011	0.023	0.19	..	..	..	0.001	..	0.007	0.003	10.0 FeSi 0.0 FeCTi	1.0	2–4	Slightly abnormal
8	C	0.14	0.47	0.008	0.022	0.21	..	..	..	0.003	..	0.004	0.002	10.0 FeSi 4.0 FeCTi	0.5	1–4	Slightly abnormal
9	C	0.14	0.46	0.009	0.028	0.19	...	..	..	0.002	..	0.005	0.002	10.0 FeSi 6.0 FeCTi	0.0	3–4	Slightly abnormal

NOTE: Ni and V were nil in steels 1–5 and not determined in the remainder.

* The manganese content of the ferro-manganese was in all cases 80 per cent. The silicon content of the ferro-silicon was 80 per cent for steels 1 and 2, and 50 per cent for steels 3 and 4. The ferro-silicon, zirconium had 52 per cent silicon and 39 per cent zirconium. The analysis of the deoxidizers used for the remaining steels is not known.

austenitizing temperatures, each steel was treated in both manners. An austenitizing temperature of 1650 F for the molybdenum steels and 1600 F for the carbon steels was used; specimens being held at temperature one-half hour before cooling. The molybdenum steels were treated in the form of small bars approximately $^1/_2 \times 1^1/_2$ in. in cross-sections, and the SAE 1015 steels as 1-in. rounds. Air cooling was accomplished by removing the bars (4 to 6 in. long) from the furnace and setting them on end on refractory bricks; the end in contact with the brick was discarded.

Tempering

In most elevated temperature service such steels are used at temperatures under 1100 F and, in fact, mostly below 1000 F; with this in mind, tempering temperatures of 900, 1000, and 1100 F were chosen. Tempering periods were 5, 15, 50, 100, 300, 500, 1000, 3000 and 5000 hr, a separate specimen being used for each period.

Hardness Measurements

Vickers Hardness (20 kg load) was measured in investigating the results of tempering. Not all specimens were examined in this way, but in general only those needed to determine temperature-time hardness trends. The semi-log plot was chosen for convenience and because many solid-state reactions proceed in such a fashion that the semi-log plot is linear. Departure from a straight line, therefore, may be taken as an indication of the occurrence of effects other than simple spheroidization.

Carbon Steels

The several steels show a similar variation in hardness with time at temperature, i.e., hardness decreases with increasing time beyond 5 hr, in an approximate though not exact linear manner on the semi-logarithmic scale. Graphitization, detected metallographically in the specimens tempered for the longer periods, evidently had not progressed sufficiently to affect the hardness.

A curious fact is the seeming independence of the rate with respect to temperature and the small differences in hardness developed at different temperatures. Another curious observation, in a few of the normalized and in all the annealed specimens, is the increase in hardness over that of the original caused by the 5-hr tempering. This is particularly evident in the annealed steels in which some increase is retained up to 1000 hr at temperature. It indicates that some process other than simple spheroidization is occurring. The effect, perhaps a precipitation hardening, appears to be greatest at 900 F in the normalized samples and at 1000 F in the annealed samples, and is great enough to cause the hardness of the annealed samples, which initially was some 15 points softer, to increase to a level comparable with that of the normalized series. The effect of larger aluminum addition with simultaneously smaller titanium addition is not large enough or clear enough to warrant discussion.

Molybdenum Steels

In molybdenum steel, something other than simple spheroidization occurs at elevated temperature, but for this there is a ready explanation. On tempering such steels a fine ground-mass precipitate develops, appearing earlier the higher the temperature, and coarsening with time at constant temperature, both in the manner of a typical precipitation-hardening system. Correspondingly, the change is reflected in the hardness. Owing to this precipitation, it becomes difficult to separate the effect of precipitation from that of spheroidization and agglomeration.

The effects of agglomeration and of precipitation cannot be distinguished. Evidently the hardness as determined represents some sort of average of the hardening due to the ground-mass precipitate and the softening which accompanies spheroidization and agglomeration of the carbide and of the precipitate. At the lower temperature, hardening predominates; at the higher, softening predominates.

The annealed samples all show much less evidence of either softening or hardening than the normalized. The reason for this may be that equilibrium is more nearly attained during the slower cooling, while the lesser softening may be attributed to the coarser carbide which likewise results from slower cooling. It may also be noted that, as in the annealed carbon steels, short-tempering of the annealed samples increases hardness. With respect to the effect of aluminum on the retention of hardness, comparisons for steels Nos. 3 and 4 and for steels Nos. 1 and 2, at the low and high silicon levels, respectively, show in both, that aluminum addition lowers the hardness of normalized material, and that this difference is preserved during tempering.

The effect of varying silicon cannot be evaluated owing to other differences in composition. For example, of the three steels (Nos. 2, 3 and 5) to which no aluminum addition had been made, steel No. 5, with the lowest silicon addition, had the greatest hardness in the normalized condition and best retained hardness on tempering at each temperature; but the silicon was added as Fe-Si-Zr and there was an appreciable chromium content. The behavior of the annealed samples is not in conformity with the relationship noted for the normalized samples, though the spread is of a minor nature and probably not significant.

Initial Structures

The greatest difference is found between the annealed and the normalized states. The molybdenum steels were more noticeably affected by variation in deoxidation practice, particularly in the normalized condition. As in the carbon steels, and for the same reasons, the furnace-cooled samples spheroidized more slowly than the normalized. Moreover, as a whole, the molybdenum steels were more resistant to spheroidization owing, perhaps, to the necessity for diffusion not only of carbon, but also of molybdenum, a process which occurs at an appreciably slower rate than for carbon.

Three arbitrary stages of spheroidization and graphitization were established: (1) first detectable change; (2) intermediate; (3) advance change. The time required to reach these stages is shown in Table 2.

Graphitization

It is interesting that the three molybdenum steels that graphitized were those to which aluminum had been added in the mold, and of these three, that with the highest silicon, No. 1, graphitized to the greatest extent and that with the lowest silicon, No. 6 least (in spite of having the large aluminum addition of 3 lb per ton)

TABLE 2—PROGRESS OF SPHEROIDIZATION AND OF GRAPHITIZATION, AS OBSERVED AFTER 5, 15, 50, 100, 300, 500, 1000, 3000 AND 5000 HR AT TEMPERATURE

		Main Deoxidizers Added		Hours to Reach Stage of Spheroidization									Hours to Reach Stage of Graphitization (blank spaces indicate none detected within 5000 hr at temperature)								
				900 F			1000 F			1100 F			900 F			1000 F			1100 F		
No. of Steel	Type of Steel	Ladle, Lb/Ton	Mold, Lb Al/Ton	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Normalized Specimens																					
1	Mo	12.6 FeSi	1.0	100	3000	*	5	1000	3000	5	15	100									
2	Mo	12.6 FeSi	...	3000	*	*	5	500	3000	5	50	300									
3	Mo	7.7 FeSi	...	5000	*	*	100	3000	5000	50	300	500									
4	Mo	7.7 FeSi	1.5	5000	*	*	50	500	1000	5	50	300									
5	Mo	5.1 FeSiZr	...	3000	*	*	500	1000	3000	50	100	300									
6	Mo	......	3.0	5000	*	*	1000	3000	5000	100	300	1000				5000	*	*	3000	*	*
7	C	10 FeSi 0 FeCTi	1.0	1000	3000	5000	50	500	1000	15	50	300				5000	*	*			
8	C	10 FeSi 4 FeCTi	0.5	300	1000	3000	100	500	1000	5	50	300				5000	*	*	1000	*	*
9	C	10 FeSi 6 FeCTi	0.0	50	500	1000	5	500	1000	5	15	50					5000	*	5000	*	*
Annealed Specimens																					
1	Mo	12.6 FeSi	1.0	5000	*	*	300	1000	3000	15	100	300	5000	*	*	1000	3000	5000	300	1000	5000
2	Mo	12.6 FeSi	...	5000	*	*	500	3000	5000	15	100	500									
3	Mo	7.7 FeSi	...	5000	*	*	300	3000	5000	100	300	1000									
4	Mo	7.7 FeSi	1.5	5000	*	*	50	300	5000	5	100	500				3000	*	*	1000	3000	*
5	Mo	5.1 FeSiZr	...	5000	*	*	300	3000	*	50	300	500									
6	Mo	......	3.0	5000	*	*	500	*	*	100	300	1000				5000	*	*	1000	*	*
7	C	10 FeSi 0 FeCTi	1.0	5000	*	*	50	300	1000	15	100	500				5000	*	*			
8	C	10 FeSi 4 FeCTi	0.5	5000	*	*	50	300	500	15	100	500				5000	*	*	3000	*	*
9	C	10 FeSi 6 FeCTi	0.0	300	*	*	50	300	1000	15	50	300				3000	5000	*		3000	*

* Greater than 5000 hr (limit of observation).

It is also interesting, and perhaps unexpected, that graphitization proceeded more extensively in the annealed than in the normalized specimens. In fact, only in steel No. 6, which incidentally contained an appreciable chromium residual, 0.17 per cent, was graphite detected in the normalized molybdenum steels. The use of titanium as a stabilizer of carbide and graphite inhibitor is under investigation at the present time.

In the carbon steels, the extent of graphitization or the time for its appearance was apparently independent of initial conditions, i.e., whether normalized or annealed, and no clear relation to deoxidation practice is apparent. In both series, graphite appears generally to form faster the higher the temperature that exists within the range studied.

In this connection it has been suggested that the type of structure developed in the carburizing test may be indicative of susceptibility to graphitization according to the following scheme: Steels which show a so-called "abnormal" structure are prone to graphitize, while those which show a "normal" structure are resistant to graphitization. It is apparent that for the molybdenum steels there seems to be a correlation between graphitization tendency and degree of "abnormality." That is, those which graphitized within 5000 hr (steels 1, 4 and 6) were those to which aluminum addition had been made and which were both fine grained and "abnormal." Whether this is always the case, and whether "normal" steels are indefinitely resistant to graphitization, cannot be decided on the basis of these limited studies. It is suspected, however, that the apparent relationship can only come about through an accelerating effect of the aluminum addition (which tends to produce "abnormality") on the rate of graphitization, not on the thermodynamic stability of the graphite relative to the carbide present.

The fact that spheroidization is apparently accelerated by aluminum additions and that (in the molybdenum steels) graphitization occurred only in steels to which aluminum had been added, indicates some sort of relationship between the two phenomena. This does not mean, however, that spheroidization must precede graphitization. Perhaps aluminum addition serves to increase the diffusivity of carbon and thus spheroidization and graphitization, while the alumina particles resulting from deoxidation aid somehow in nucleating graphite.

Summary

The hardness of most of the carbon steel samples first increased slightly with time at temperature, then decreased slowly at about the same rate at each of the three temperatures; the changes appeared to be uninfluenced by the deoxidation practices used. The increase was greatest in the annealed samples held at 1000 F. The hardness of the annealed molybdenum steels followed the general pattern of the carbon steels, but the normalized samples behaved in a way characteristic of precipitation-hardening systems; that is, the hardness increased initially, more slowly but to a higher value the lower the temperature, and then decreased. This phenomenon combined with the simultaneous spheroidization and agglomeration of the carbide makes the picture of the hardness change less simple than that for the carbon steels and annealed molybdenum steels.

The rate of spheriodization of the normalized steels was generally greater than for the annealed steels, as is to be expected from the finer initial structure, but the effect was less marked in the carbon steels. In the normalized carbon steels the rate was highest in the high titanium-treated steel. In the molybdenum steels the rate increased with increasing silicon plus aluminum addition, whereas a large aluminum addition without silicon was associated with a lower rate which, however, is probably to be attributed to a coarser initial microstructure.

Graphite formed in all the carbon steels, and at about the same rate in both normalized and annealed specimens. In the six molybdenum steels, it formed only in the three to which aluminum had been added. In these three the rate seemed to be faster the higher the silicon content, and in the annealed rather than in the normalized samples, only one of which showed graphite. In both groups graphitization was generally faster the higher the temperature existing within the particular range studied.

A great deal of further work is needed, particularly on the nature of carbides, how they depend on the presence of alloying elements, whether added as such or as deoxidizers, and how the carbides are modified by temperature and time. Obviously, therefore, many of the outstanding questions cannot be answered in the immediate future.

Tube Failures in Water-Tube Boilers

• The article under this title, by John Van Brunt in the July issue of COMBUSTION, created widespread interest and resulted in many requests for reprints which have now been made available. One unusual type of tube failure that was not covered in the original article pertains to floor tubes in slag-bottom furnaces. This is covered in the following supplement prepared by Mr. Van Brunt.

An unusual type of tube failure occurring only in slag-bottom furnaces is due to the flow of fluid slag over a small area of a tube in a short period of time. The action may be considered as similar to an acetylene torch in that the heat input to a limited area is tremendously high.

A flow of as little as 20 lb of fluid slag for two or three minutes confined to an area of one square inch will melt the metal and virtually pierce the tube.

The heat applied to a portion of a tube may be readily calculated. It is only necessary to assume the weight of slag flowing, the time or duration of flow and the temperature drop of the slag. For example, 20 lb of slag at 2800 F flows in a small stream for two minutes over an area of one square inch. The temperature drop of the slag is, say, 200 deg; that is, to 2600 F. Taking the specific heat of slag at 0.11 we have $20 \times 200 \times 0.11 =$ 440 Btu in two minutes, or 13,200 Btu per hr on one square inch. The rate per square foot is $13{,}200 \times 144$ or 2,880,800 Btu. This rate is more than sufficient to melt steel.

Greater weight over a much larger area will remove a substantial portion of a tube wall. The controlling factors are weight of slag, temperature drop, area in contact and time.

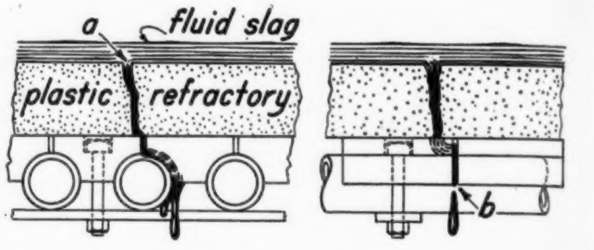


Fig. 14—Illustrating how flow of molten slag through crack can damage tube

Fig. 14 shows how this has happened in a floor tube of a slag bottom furnace. When the slag cools a crack may develop at *a*. When the boiler is back in service fluid slag can flow down the crack and between the cast-iron blocks on to the tube as indicated. If there is space below into which slag can flow the tube will be perforated. If, however, the slag cannot flow beyond the line *b* failure is not probable as sufficient weight of molten slag cannot flow over the tube.

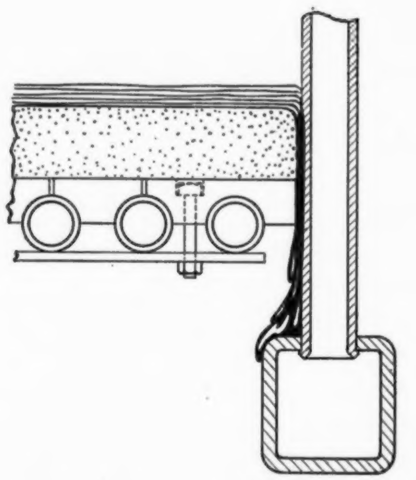


Fig. 15—Illustrating slag flow between bottom and side walls

Cracks between the bottom and the furnace side walls may result in slag flow that will melt or otherwise seriously damage a wall tube. Fig. 15 shows such a condition.

Fluid slag not flowing will chill quickly and there will be no failure of the tube.

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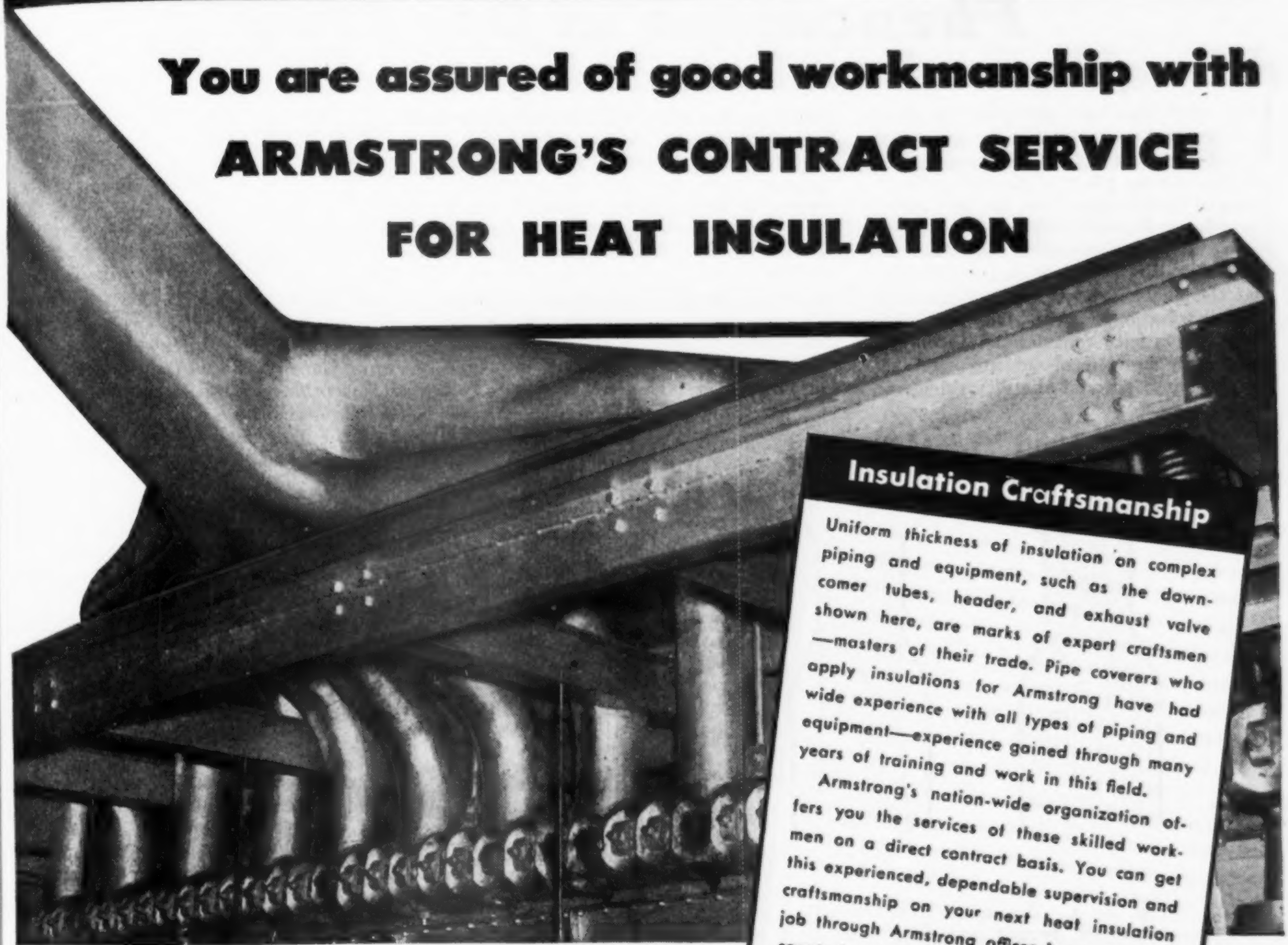

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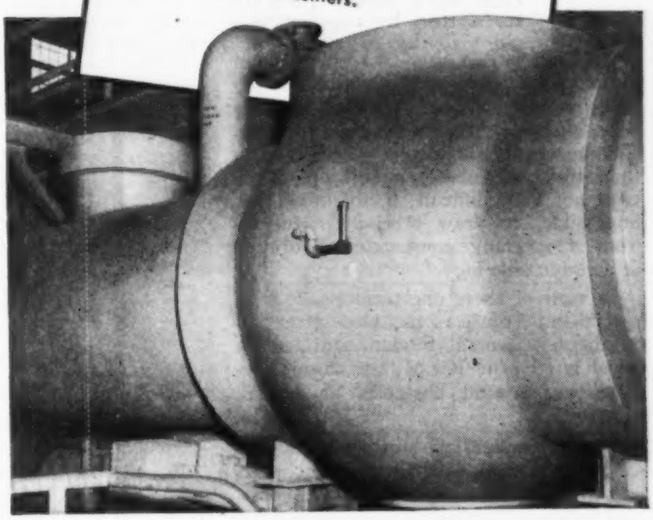

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Phenomena of Gas Flow*

In spite of their influence upon the utilization of the convection heat-absorbing boiler surface, the aerodynamic phenomena taking place along the path of travel of the flue gases from the furnace to the boiler outlet and beyond do not always receive the attention which they deserve. This, of course, is largely due to the fact that the analytical treatment of the gas flow distribution in the various boiler passes meets with considerable difficulty, particularly in view of the impossibility of taking into account the disturbing influences of uneven combustion and heat-absorbing conditions prevailing in the boiler furnace. Moreover, the presence of imponderable influences of this kind in the actual boiler plant makes it more often than not very difficult, if not altogether impossible, to draw precise conclusions from a specially constructed hydraulic or aerodynamic model.

In view of these uncertainties, it is of special importance to pay close attention to the few general fundamental factors which govern the flow of gases through restrictions, around obstacles and along bends.

Where the flue gas or the combustion air passes through a duct at constant speed and in uniform flow distribution, the friction between the flowing medium and the surfaces of the duct is the only factor which needs to be taken into account in order to determine the friction loss suffered by the fluid. Also, where an acceleration of the gas flow is caused by restrictions of flow area or by the presence of nozzles and similar devices, it is only the transformation of pressure head into velocity head which has to be taken into consideration.

Referring to a typical case of flow restriction caused by a diminution in the flow area of a duct as illustrated in Fig. 1-a, a restriction of this kind will cause a change in the pressure from a value p_1 to a lower value p_2. But this transition is seen to be accomplished without the production of vortices or other flow disturbances. Corresponding losses are not therefore incurred, and this holds true even in the case of sudden restrictions in flow area.

In contrast to this, a diminution in the flow velocity caused by an enlargement in the flow area does not result in an analogous condition. This is due to the fact that the body of flowing gas will not enlarge its cross-section sufficiently rapidly upon its passage through the restriction, and a vortex formation, as indicated in Fig. 1-b, will therefore ensue. It is obvious that the energy consumed in the creation of these vortices must derive from the energy of the flowing gas. Therefore, the decrease in flow velocity from the higher velocity prevailing in the restriction to that corresponding to the enlarged flow area on the downstream side of the restriction will not result in full recovery of the pressure head originally consumed in speeding up the flow of the gas in the restriction.

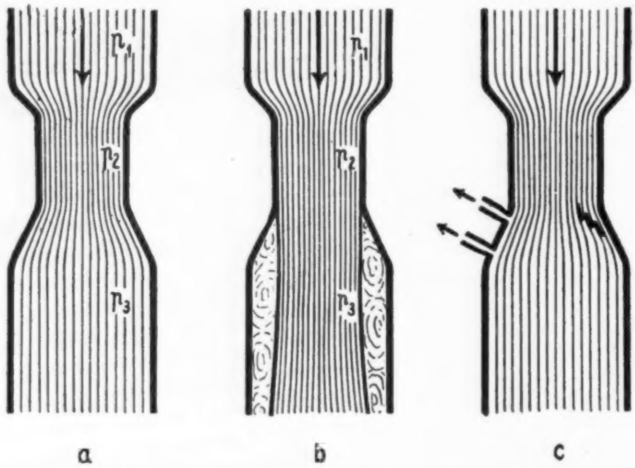


Fig. 1—a. Transient flow condition preceding establishment of permanent flow condition with vortex formation as shown in Fig. 1-b. b. Permanent flow condition with vortex formation. c. Elimination of vortex formation by aspiration of vortex formation (left-hand side) or by provision of guide vanes (right-hand side)

It is interesting to note the manner in which the formation of these vortices takes its inception from the stationary condition. If the gas velocity is rapidly increased from rest, the linear flow shown in Fig. 1-a will be initially maintained. The friction between gas flow and wall will, however, soon retard the velocity to such an extent that the gas flow will become stagnant in the parts affected, thereby creating a zone in which the direction of gas flow is actually reversed, the gas flowing from the region of higher pressure to that of lower pressure. This reversed flow reacts upon the main flow and thus becomes the cause of vortex formation at the point where the flow section enlarges. The vortex will then rapidly spread out until it fills the entire section of enlargement. As the initial cause of vortex formation is thus found to be the formation of a zone of stagnation, it is but reasonable to assume that vortex development can be prevented by suppressing the formation of such a zone.

One possible remedy will, therefore, consist in the withdrawal of gas from the main stream by tapping the gas duct as indicated in the left-hand side of Fig. 1-c.

Another frequently applied measure is the installation of guide vanes in the critical zone, as shown in the right-hand side of Fig. 1-c. One or the other of these preventive measures is sometimes used where it is essential to insure uniform flow dis-

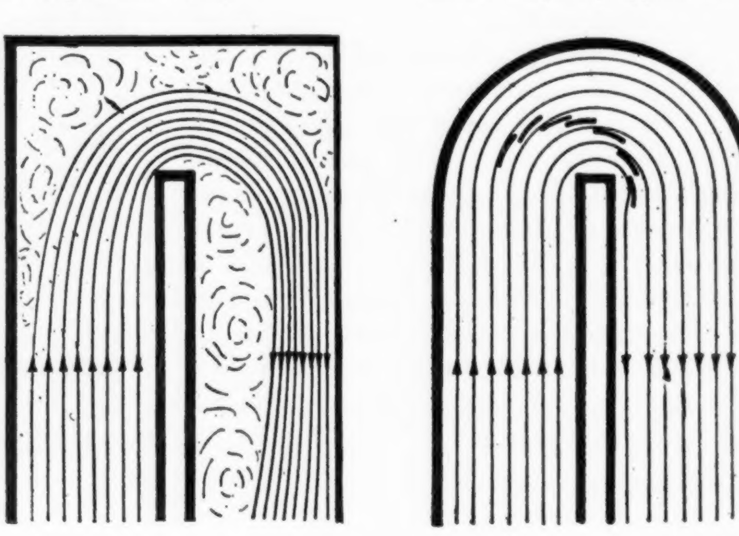


Fig. 2—a. Irregular flow distribution and vortex formation. b. Enforcement of uniform flow distribution by means of guide vanes

* Reproduced in part from an article in the July 1945 issue of *Engineering and Boiler House Review* (London).

tribution throughout the flow area so as to safeguard satisfactory convection heat transfer in all parts of the heat-absorbing surface passed by the gas flow. In this case, diminution of the draft loss by the suppression of vortex formation is of only minor importance.

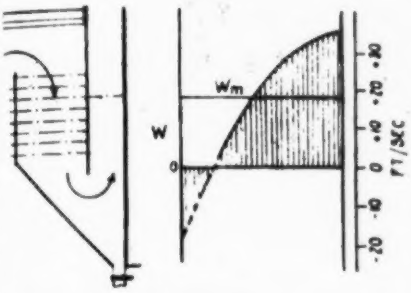


Fig. 3—Gas velocity distribution in gas pass after change in direction of flow by 180 deg

Effects of Changes in the Direction of Gas Flow

The effects of changes in the direction of gas flow caused by boiler baffling are exemplified by Figs. 2 and 3. Referring to Fig. 2, it is seen that the gas stream, having passed around the baffle, is by no means uniformly distributed over the available cross-sectional flow area. Actual tests have shown that at the points of maximum flow concentration immediately past the baffle, the gas speed may be twice the velocity corresponding to the clear area of the pass. Such a flow concentration must necessarily lead to a draft loss that cannot be neglected when estimating the overall draft loss of the boiler. Where the pass on the downstream side of the baffle does not contain any tubing, the loss may well be halved by the installation of guide vanes as indicated in Fig. 2-b.

In the case of changes in flow direction by 90 deg, the draft loss will be considerably less than for 180 deg; but here the installation of guide vanes may prove worth while, particularly where high gas velocities are concerned. Similar conditions exist in baffle arrangements of the type shown in Fig. 3, where the approximate gas velocity distribution past the 180 deg deflection is also indicated.

Where the baffles are arranged vertically between the banks of bent-tube boilers, the ensuing sharp deflections of the gas flow may even endanger the boiler tubing if the gases are laden with considerable amounts of abrasive cinders.

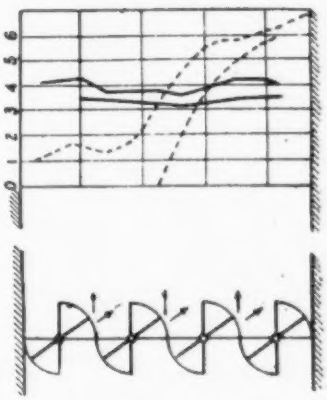


Fig. 4—Gas velocity distribution in duct after damper

Another source of flow disturbance is the presence of flue gas dampers in the gas duct. Referring to Fig. 4, it will be seen that uniform gas flow distribution throughout the flow area at the downstream side of the multiple-type damper exists when the damper is in the wide-open position. However, as soon as the damper is brought into the partially closed position, the gas flow distribution (in this case measured at a distance of some 8 ft on the downstream side) will be found to be displaced to one side of the duct, as indicated in the graph. It need hardly be emphasized that a flow displacement of this kind may seriously affect the convection heat transfer in a heat-absorbing apparatus at the downstream side of the damper. The installation of flow-directing vanes in cases of this kind appears to be fully warranted.

In considering the draft requirements of a boiler, or, in fact, of any convection heat-absorbing device, a distinction must be made between useful and wasteful draft losses. Heat transfer by forced convection can be obtained only by the incurrence of a draft loss, and every kind of convection heat-absorbing device will therefore have an inherent useful draft loss, plus a wasteful draft loss, the magnitude of which depends upon the particular design of the apparatus.

There exists a functional relationship between inherent draft loss and specific surface requirements, and the optimum useful draft loss can therefore be determined on the basis of economic considerations. To a large extent wasteful draft losses can be precluded by adequate design, but where additional capital expenditure would be required for this purpose, economic considerations must, of course, apply. Draft losses caused by changes in the direction of the gas flow can, with sufficient accuracy, be expressed in terms of the velocity head of the gas flow as

$$D_1 = k(\gamma v^2/2g) \text{ lb per sq ft}$$

where k is the "loss of velocity head" factor and v is the velocity of the gas flow in feet per second, while γ is the density of the gas in pounds per cubic foot. A few experimental data on the magnitude of the velocity head factor for various types of flow deflections are listed in Fig. 5.

Where guide vanes or similar devices would be required in the elimination of wasteful draft loss, the question of upkeep must not be overlooked. In cases where considerable wastage and frequent replacement of guide vanes is to be expected, it may be found that the incurrence of a certain amount of wasteful draft loss must be tolerated on purely economic grounds.

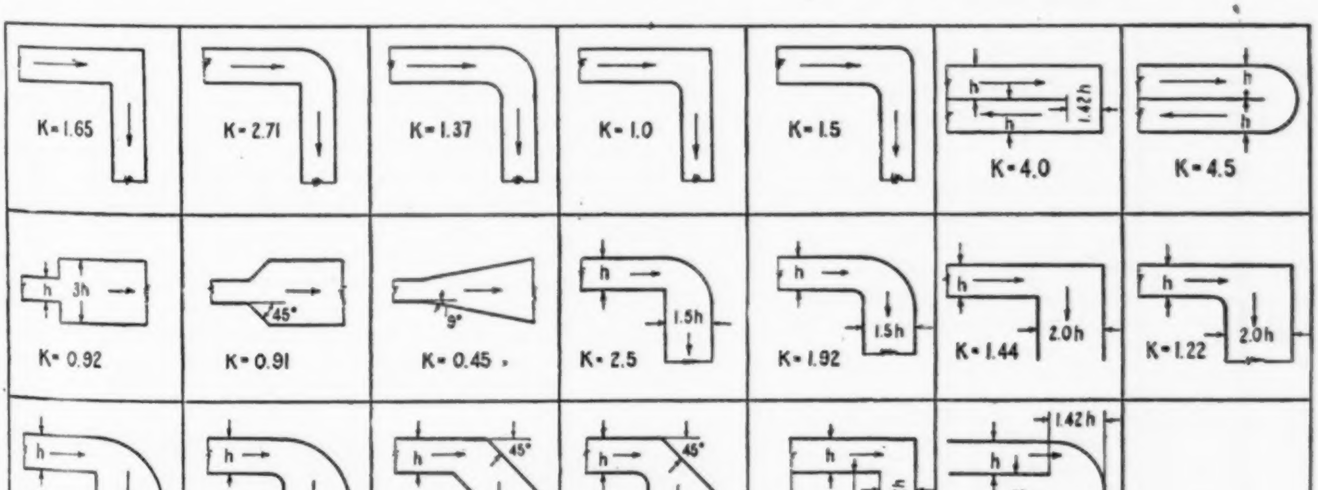


Fig. 5—Diagrams of experimental data on the magnitude of the velocity head factor for various types of flow deflections

The Bituminous Coal Outlook Still Unsatisfactory

LATE reports from the Solid Fuels Administration indicate that bituminous coal requirements by industrial groups have been reduced very little by Japan's defeat. This also applies to requirements by the Armed Services. Surveys place the nation's coal needs at between 570 and 585 million tons of soft coal for the fuel year ending March 31, 1946, and it is anticipated that present available mine manpower will make it difficult to meet these requirements.

Due to slight seasonal decreases in industrial consumption during July, stockpiles were increased, but by August first they were still about $11^{1}/_{2}$ million tons short of those of the corresponding date in 1944. Loss in coal production, through sporadic strikes, amounted to more than a million tons in August, and since April first such loss has totaled approximately 13 million tons. Moreover, celebration of Japan's defeat resulted in a 60 per cent loss in coal output during the week ending August 18.

The average number of days' supply on hand by the principal classes of consumers was: electric utilities 73, by-product coke ovens 19, steel and rolling mills 27, coal-gas retorts 50, cement mills 46, railroads 31, miscellaneous industries 51, and retail dealers 21; all averaging 37.

Soft coal requirements, determined from data submitted by the Solids Fuels Requirements Committee (representing the Army, Navy, Marine Corps, Office of War Utilities, Office of Defense Transportation, WPB, OCR, F.E.A., the State Department and OPA), adjusted to reflect the effect of the end of the war are shown in the following comparisons for the year ending March 31, 1946:

	Present Estimates	Pre-VJ-Day Estimates
Railroads (all classes)	127,000,000	139,000,000
Electric power utilities	76,500,000	77,900,000
Coke ovens, steel mills—		
Beehive	5,700,000	9,000,000
Byproduct	86,500,000	94,300,000
Steel, rolling mills	10,000,000	10,600,000
Coal gas retorts	1,500,000	1,550,000
Retail and direct truck deliveries	127,000,000	117,300,000
Colliery fuel	2,700,000	2,700,000
Cement mills	4,800,000	3,750,000
Lake vessel fuel	1,500,000	1,500,000
Tidewater bunker fuel	1,800,000	1,800,000
Manufacturing, misc.	98,000,000	110,600,000
Exports	42,000,000	30,000,000
Total	585,000,000	600,000,000

From this it will be seen that the end of the war is expected to have surprisingly small effect on many of these groups, despite some earlier predictions.

The reduction in anticipated railroad fuel needs is not at all in proportion to the drop in the industrial index or the general level of employment. With the demobilization of troops and the post-war shifting of the population, passenger traffic, which accounts for one-fifth the railroad coal, will be undiminished. Although a 15 per cent reduction in freight traffic during the last four months of 1945 would reflect a 12 per cent reduction in coal requirements, the movements of basic industrial commodities are expected to be high for the remainder of the coal year.

No marked decrease in the coal requirements of electric utilities is anticipated, as civilian production in general has higher power requirements per man-hour than was true for war industries. Public utilities ordinarily consume 15 per cent of the total soft coal supply.

Demands by Steel Industry Still High

Data from the Iron and Steel Branch of WPB indicate that steel output will decline relatively less than will industrial activity generally, because of the demand for steel in reconversion. Steel and coke production account for about 20 per cent of the soft coal production.

The Army and the Marine Corps expect their requirements of coal for space heating to be slightly increased as more camps will be activated in the United States than otherwise would have been the case.

The requirements of cement mills are expected to increase because of greater activity in building construction, also public works construction.

The considerable decline in estimated requirements by manufacturers reflects the passing of war production and delays in manufacturing operations incident to reconversion. However, many industrial concerns now have extremely low stockpiles and will continue to purchase coal in an effort to build up their inventories against contingencies. General manufacturing utilizes about 15 per cent of the total soft coal supply.

Exports, which comprise about 5 per cent of the total soft coal output, are expected to increase sharply, except for Canada which will require approximately 22 million tons. This is slightly less than that of recent years. American shipments abroad will increase because of European needs, but the amount to be shipped will likely be less than has been requested. An increase is also expected in shipments to South America.

The threatened shortage of coal applies largely to the East as there appears to be an adequate supply of Western coals; but unfortunately, lack of transportation and the unsuitability of much of the Western coals to the particular needs of the East render it difficult to make up the deficit from surplus in the West.

The Solid Fuels Administration has notified all shippers to industrial consumers of coal moving via the Great Lakes that their commitments must be reduced immediately by 5 per cent. It was pointed out that this reduction was made necessary by production losses which prevented shippers from meeting their scheduled lake deliveries.

Dangers of Hydrogen Sulphide in "Sour" Crude Oils

Failure to take proper precautions to avoid exposure to hydrogen sulphide has resulted in several deaths and many serious injuries, says the Bureau of Mines. Because of the more widespread use in recent years of "sour" or high-sulphur content crude oils, the chances of exposure to hydrogen sulphide poisoning have increased. However, while the "sour" crude oils have been known to give off dangerous hydrogen sulphide gas during the production, transportation, storing and refining processes, the fully refined petroleum products are free of the gas.

Although carbon monoxide commonly has been considered as extremely toxic, Bureau of Mines studies have shown that hydrogen sulphide is five or six times as toxic. It exerts a marked irritant action on the cornea of the eye, even in low concentrations, and in larger concentrations causes asphyxia and even death.

"Sour" gas is now being burned under boilers in some sections of the Southwest.

A report, Information Circular 7329, has recently been issued by the Bureau, describing the physiological action of the gas, treatment for hydrogen sulphide poisoning, detection of the gas and preventive measures.

Utility Output and Demand

July 1945 output of electric energy by Class 1 Electric Utilities was 0.9 per cent over that of July 1944 and peak demands were up 3.3 per cent, according to data compiled by the Federal Power Commission. The Southeast led in both the percentage of increased output and the demand, whereas the Northwest and the Southwest fell off in both these categories. The total July output for the country was 18,672,965,000 kwhr and the demand aggregated 37,115,194 kw.

Latest available figures on dependable capacity, less required generating capacity reserves, totaled 40,246,118 kw as of July 1, 1945, with scheduled additions expected to raise the figure to 41,047,278 kw by the end of the present year. Dependable capacity before deduction for reserves, was 44,122,408 kw, and on the basis of additions that have been scheduled for completion by December 31, will be 44,944,173 kw.

Coal consumption by private electric utilities in July 1945 was 6,326,873 tons—an increase of 103,378 tons over June. Of this 6,062,168 tons was bituminous coal—an increase of 1.5 per cent over that for June. Fuel oil consumption increased 12.8 per cent and gas 11.5 per cent.

The combined utility and industrial production of electric energy for July 1945 is given as 23,050,174,000 kwhr, an increase of 0.4 per cent over the corresponding month of 1944.

Revenues of the larger privately owned electric utilities in July 1945 were $259,347,000 as compared with $252,310,000 for July 1944. However, net income, after deducting operating expenses, depreciation and taxes decreased by approximately 2.8 per cent.

ANNUAL WATER CONFERENCE

Starting Monday morning, October 22, the Sixth Annual Water Conference will devote two full days to sessions covering ten major topics in the field of water treatment for boilers and for industrial use. Each topic will be the subject of a paper followed by several prepared discussions by specialists. The Conference, which is sponsored by the Engineers' Society of Western Pennsylvania, will be held at the Hotel William Penn, Pittsburgh, and the following program has been prepared:

Monday Morning, 8:45 a.m.

Chairman, Dr. E. P. Partridge, Director of Research, Hall Laboratories

"Hot Lime Soda of Spaulding Precipitator Design," by S. B. Applebaum, Vice President, Permutit Co. Discussions by C. E. Joos, Cochrane Corp.; M. C. Schwartz, Engineering Experiment Station, Louisiana State University; Charles Spaulding, consulting engineer, Springfield, Ill.

"Experimental Studies of Boiler Scale at 1500 Psi," by J. A. Holmes, Asst. Vice President, National Aluminate Corp. Discussions by C. E. Imhoff, Allis Chalmers Mfg. Co.; W. L. Webb, American Gas & Electric Co.; R. K. Scott, Hall Laboratories; J. B. McIlroy, Babcock & Wilcox Co.; S. T. Powell, chemical engineer.

"How to Evaluate Data," by V. V. Kendall, corrosion engineer, National Tube Co. Discussions by Max Hecht, consulting engineer, Pittsburgh; R. C. Adams, U. S. Naval Experiment Station; A. A. Berk, U. S. Bureau of Mines.

Monday Afternoon, 2:00 p.m.

Chairman, Dr. S. F. Whirl, Duquesne Light Co.

"Behavior of Highly Concentrated Boiler Water," by C. E. Kaufman, V. M. Marcy and W. H. Trautman, research engineers, Hall Laboratories. Discussions by M. D. Baker, West Penn Power Co.; R. C. Corey, Combustion Engineering Co.; T. J. Finnegan, Buffalo Niagara Electric Corp.; S. F. Whirl, Duquesne Light Co.

"Cold-Water Vacuum Deaeration (Results, Operating Data, and Costs)," by Sheppard T. Powell, chemical engineer. Discussions by J. R. McDermet, Elliott Co.; J. D. Yoder, Permutit Co.; Merrill L. Riehl, chemical engineer; C. F. Terrell, Pure Oil Co.; A. E. Kittredge, Cochrane Corp.; F. N. Speller, consulting engineer.

Tuesday morning, 9:30 a.m.

Chairman, R. D. Hoak, Mellon Institute

"Treatment and Preparation of Water in Rayon Textile Mills," by William Habbart, American Viscose Corp. Discussion by F. R. Owens, Cyrus Wm. Rice Co.; L. B. Miller, chemical engineer, W. H. & L. D. Betz; H. R. Hay, Philadelphia Quartz Co.; Richard Sitzler, Celanese Corp. of America.

"Construction and Maintenance of Water Wells," by N. E. Gunderson, Layne Northern Co. Discussions by E. W. Bennison; A. M. Buswell, Illinois State Water Survey; C. A. Bays, Illinois State Geological Survey; J. R. Charles, Layne New York Co.

Tuesday afternoon, 1:45 p.m.

Chairman, D. S. McKinney, Carnegie Institute of Technology

"Ionic Exchangers," by F. K. Lindsay, National Aluminate Corp. Discussions by M. J. Shoemaker, Research Products Corp.; M. E. Gilwood, Permutit Co.; E. R. Mueller, Resinous Products & Chemical Co.; Dr. W. C. Bauman, Dow Chemical Co; W. E. Manring, American Cyanamid & Chemical Corp.; W. S. Morrison, Illinois Water Treatment Co.

"Electrolytic Water Softening for Industrial Purposes," by R. E. Briggs, Metropolitan Water Dist. of Southern California. Discussions by Dr. Edward Bartow, Iowa University; Dr. C. G. Fink, Columbia University; Lee Streicher, Metropolitan Water District of California; A. C. Embshoff, Infilco Co.

"Diatamaceous Earth Filtration," by H. E. Hollberg, vice president, and H. N. Armbrust, engineer, Proportioneers, Inc Discussions by F. C. Roe, The Carborundum Co.; F. L. Horine, Johns-Manville Corp.; Dr. A. B. Cummins, Johns Manville Corp.

Constitution of Mild-Steel Arc-Weld Deposits

In 1943 the Advisory Service on Welding of the British Ministry of Supply invited the cooperation of the National Physical Laboratory to assist in building up the scientific background of ferrous arc welding by an investigation of certain problems such as, (1) the rôle which hydrogen plays in causing or assisting in the formation of cracks in the weld deposit or in the heat-affected zone of the parent metal; (2) the form in which elements such as manganese and silicon exist in weld metal, as affecting properties of the material; and (3) the relative effects on the hardness of weld metal of carbon and nitrogen. The results of preliminary investigations of these problems have been reported in a paper by Messrs. Sloman, Rooney and Scofield, before The Iron and Steel Institute. A summary of their findings follows:

Six different mild-steel electrodes having coatings of both iron oxide-silica and the titanium-oxide types, with a wide range of potential hydrogen contents, were examined.

The moisture contents of the various coatings were determined at both 600 C and 1200 C, the moisture including that produced by the combustion of the organic constituents of the coatings (where present). It was found that at least 80 per cent of the water is evolved at 600 C.

The total hydrogen contents of the weld deposits were determined and, for a given electrode, were found to be approximately constant and proportional to the total hydrogen available during deposition. In any deposit the total hydrogen can be divided into two portions, one of which escapes slowly at room temperature, while the other is apparently held permanently in the metal.

While the total hydrogen in welds made with a given electrode is constant, the proportion evolved in the cold varies considerably. More may be evolved from a weld made with an electrode having a coating with a low total potential hydrogen than from one with a relatively high potential hydrogen. This variability could not be controlled under the conditions of the experiments and no satisfactory explanation has been forthcoming to account for it.

Although the total oxygen in welds made with a given electrode is constant, the amount varies with the make of electrode. The actual amount appears to depend upon the composition of the coating rather than on that of the core wire. The results by the vacuum-fusion and alcoholic-iodine tests are in good agreement.

It was found that the composition of the electrode coating has an important influence on the composition of the deposits and on the type of the oxide inclusions. Oxides of chromium and phosphorus are present usually in small amounts only. Small amounts of aluminum were found in some of the deposits, but its influence was negligible. While some of the coatings contained a high percentage of titanium, only a very small amount is retained in the deposits. The percentage of silica in the deposits varied from 0.044 to 0.122; and, according to X-ray evidence, it was present as a silicate of manganese (rhodonite) or of iron (fayalite). Iron oxide in the inclusions varied from 0.004 to 0.2 per cent, the amount presumably depending upon the composition of the coating and the protective action of the slag formed during welding. The amount of manganese oxide in the weld was fairly constant, varying from 0.091 to 0.177 per cent. The amounts of elemental silicon and manganese in the weld are dependent on the percentages of those elements in the core wire as well as on the composition of the coating.

In the welds made by automatic processes the major constituents of the residue were found to be silica and manganese, together with small amounts of ferrous oxide. Some manganese sulphide was also detected. These percentages were much higher than those in welds made by hand.

All the deposits showed numerous inclusions which were mostly too small for detailed examination, but at least three or four types in each deposit were large enough for identification.

The appearance of the constituents in the deposits varied with the carbon and nitrogen contents; and, except for a shallow surface layer, the ferrite grains of all the deposits were very fine.

Low-temperature heat treatment after normalizing resulted in an appreciable reduction in hardness of all the deposits, except those containing the highest carbon and lowest nitrogen percentages. Microscopic examination after the low-temperature heat treatment revealed the precipitation of numerous needles, except in the deposits containing the lowest and the highest percentages of nitrogen, respectively.

All the deposits showed paler sulphur prints than the parent plate, even when the sulphur contents of the deposits and plate were similar.

Smoke Prevention Meeting at Columbus

The Smoke Prevention Association of America will hold its Annual Meeting on October 16 to 18, inclusive, at Columbus, Ohio, with headquarters at the Deshler-Wallick Hotel. Subjects to be discussed are (1) the Fuel Efficiency Campaign and its effect on smoke abatement efforts; (2) the relation of district and central heating to smoke problems of urban communities; (3) elimination of nuisances accompanying refuse and garbage incineration; (4) methods of collection of solid discharges resulting from fuel combustion; (5) standardization of methods of measuring air pollution; (6) developments in prevention of railroad smoke; (7) combustion controls and smoke abatement; and (8) the development of smokeless fuels and interpretation of fuel analyses.

The titles and authors of papers scheduled for presentation at the meeting are as follows:

"Trends in Development of Smokeless Fuels," by A. D. Singh, Illinois Inst. of Technology.

"The Locomotive Gas Turbine" (illustrated), by J. I. Yellott, Director of Research, BCR Locomotive Development.

"Application and Interpretation of Coal Analysis," by W. D. Langtry, Commercial Testing and Engineering Co., Chicago.

"Some of the Uses of Meteorological Methods of Smoke Prevention," by C. Dillon Smith, Senior Meteorologist, United States Weather Bureau.

"Undergrate Air Distribution on Locomotives," by Vaughn Mansfield, Chief Engineer, Southern Coal Co., Memphis, Tenn.

"District Heating: Post-War Smoke Solution," by Robert L. Fitzgerald, The Duluth Steam Corporation.

"Combustion Controls and Smoke Abatement," by M. W. Crew, Perfex Corporation.

"Prevention of Black Smoke" (illustrated), by C. B. Curtis, R. F. & P. RR, Richmond, Va.

"Comments on My European Combustion Observations," by Dr. Harold J. Rose, Director of Research, Bituminous Coal Research, Inc.

New Plant for Detroit

Federal Works Administrator, Major-General Philip B. Fleming, has announced Detroit is to build a new $5,500,000 power plant to supplement the Public Lighting Commission's present facilities and thus provide generating capacity to meet anticipated peak demands until 1954. A Federal allotment of $150,000 has been made to supplement $200,000 of city funds for preparation of plans.

The new plant will be built on city-owned property along the Detroit River and the initial installation will include a 35,000-kw condensing turbine-generator designed to operate at 1650 psi and 1000 F steam temperature.

This first unit of the new plant, combined with the 80,000-kw capacity of the present plant will give the Public Lighting Commission a generating capacity of 115,000 kw. The Commission supplies power for municipal services, whereas The Detroit Edison Company supplies power for private and commercial use. The two systems are interconnected.

British Return to Brownout

Although several months have elapsed since Germany was defeated, during which time English cities were brightly lighted, the fuel situation has become so acute that British authorities are reported to have ordered a return to the "brownout" regulations involving reduced lighting on the lesser thoroughfares and the extinguishing of most street lights at midnight. Presumably display lighting is also affected by the order.

OWU to Disband

It has been announced that the Office of War Utilities is to be discontinued the end of this month, together with wartime controls which it exercised over electric utilities, except certain matters pertaining to inventories which pass to WPB. Thus priorities for power equipment and limitations on new construction, which have been eased during the past several months, are revoked.

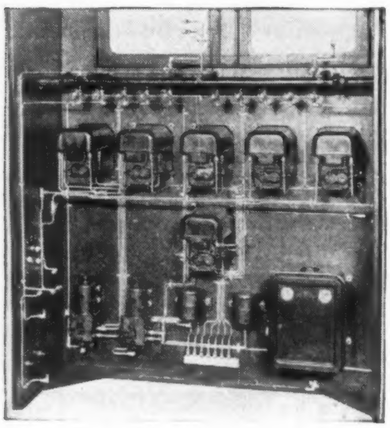
The Office of War Utilities early in the war took over the functions of the Power Branch of the former Office of Production Management and its first director was J. A. Krug, now chairman of WPB. He was succeeded about a year and a half ago by Edward Falck, who had utility experience with both the TVA and the Consolidated Edison Company of New York. In fact, many of the key men on the OWU staff were drawn from the utilities, which background was largely responsible for the smooth functioning of the Office in close cooperation with the various utilities throughout the country.

From the start the policy of OWU was to make the most of existing capacity through extensive interconnection and to authorize new construction only where absolutely necessary, at a time when the materials situation was acute. That we got through the war without any serious power shortage testifies to the soundness of this policy.

NEW EQUIPMENT

Prefabricated Boiler Control Panel

Prefabricated boiler control panels which include all necessary connecting piping and electrical wiring for the operation of metering equipment and boiler control systems are now offered by Bailey Meter Company to simplify the users problem of installation. These panels which are factory fabricated and tested by experienced instrument mechanics are said to save installation time, to insure the use of suitable materials, to reduce total installed cost, and to present a neat, pleasing appearance. All piping and wiring necessary for operation is installed as a unit according to a coordinated and prearranged plan instead of as piecemeal operations by various contractors in the field.



Small units such as valves, relays, switches, signal lights, and the more sturdy and light-weight instruments are mounted and connected ready for service. Heavy instruments or instruments having delicate mechanisms are shipped separately; but cutout spaces, drilling and all necessary connections are provided so that their installation in the field is a foolproof, quick and easy operation.

Pressure Sensitive Device

Utilizing the principle that the electrical characteristics of a wire filament change with a physical strain, the Baldwin Locomotive Works' Southwark Division has developed a pressure sensitive device that promises to open whole new fields of measurement and control.

The new instrument, called the SR-4 Pressure Sensitive Device, is used to convert gas or liquid pressure to electrical energy for measuring, recording or controlling. Its extreme accuracy, one-fourth of one per cent of full scale having been consistently obtained, will mean that the device can be used for control operations that heretofore have not been possible. It is available in several ranges up to 0-to-20,000 psi. Since it is essentially an electronic device it will enable results to be transmitted long distances whether for direct reading, recording or control.

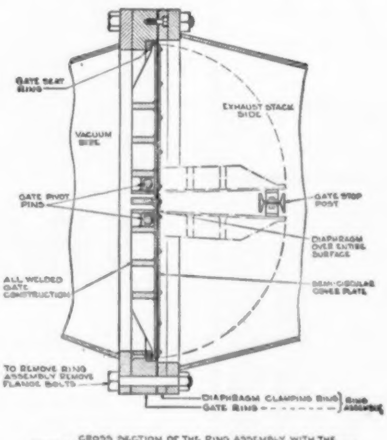
The heart of the device is a very fine fila-

ment wire bonded to a hollow metal core against which is exerted the gas or liquid pressure to be measured. As the pressure increases this filament stretches, thus changing the diameter of the wire and causing measurable changes in the electrical resistance of the wire. This change in resistance varies the amount of current flowing through the filament circuit and, when amplified, these changes show up on the dial or are used to actuate a control system. The filament is sensitive to a "stretch" of the metal core of only one-millionth of an inch.

The SR-4 Pressure Sensitive Device is hermetically sealed and an ingenious built-in compensator cancels out the effect of any extraneous force such as temperature. It is approximately one inch in diameter and five and one-half inches in length.

Atmospheric Relief Valve for Condensing Turbo-Generators

M. L. Bayard & Company announces a new atmospheric relief valve which protects a turbine against exhaust end damage should the unit go over to high pres-



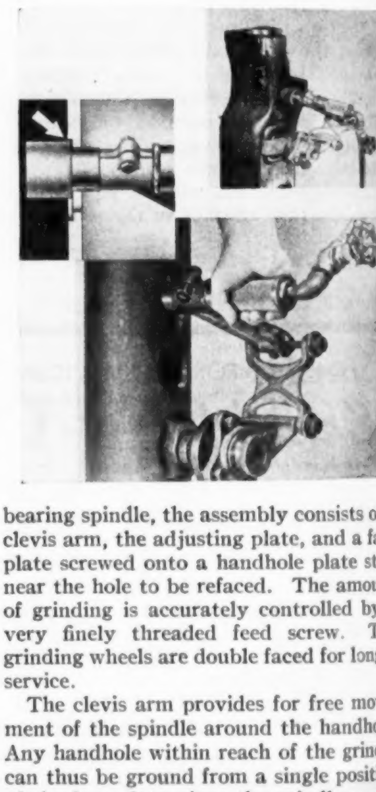
CROSS SECTION OF THE RING ASSEMBLY WITH THE GATES IN THE CLOSED POSITION. THE DOTTED LINE INDICATES THE GATES IN THE OPEN POSITION WITH THE DIAPHRAGM SHEARED PERMITTING FREE PASSAGE OF STEAM TO THE EXHAUST STACK.

sure. This valve is light and compact, and requires no access structure, stem, packing gland or water seal. The valve is so designed that upon reversal of pressure, a very thin lead disk or diaphragm is sheared mechanically by swinging gates. This shearing is accomplished well below the allowable turbine exhaust end pressure. Once the valve has been called upon to operate, replacement of the diaphragm is relatively simple. A special nonoxidizing, acid-resistant grease protects all working parts.

Available in sizes from 6 in. to 42 in. to relieve from 10,000 to 550,000 lb of steam per hour, this valve is of all-welded construction, and its cost is considerably lower than that of standard relief valves.

Handhole Seat Grinder

An automatic handhole seat grinder for use in marine and stationary boiler rooms is announced by the Lagonda Division of Elliott Company. The new grinder provides an easy, faster, more accurate means of refacing handholes of all sizes and shapes through a grinding wheel properly aligned with respect to the gasket seat by means of four screws in an adjusting plate. These assure grinding only in the plane of the gasket seat. In addition to the grinding wheel, which is mounted on a ball



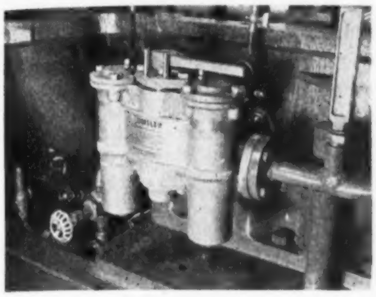
bearing spindle, the assembly consists of a clevis arm, the adjusting plate, and a face plate screwed onto a handhole plate stud near the hole to be refaced. The amount of grinding is accurately controlled by a very finely threaded feed screw. The grinding wheels are double faced for longer service.

The clevis arm provides for free movement of the spindle around the handhole. Any handhole within reach of the grinder can thus be ground from a single position of the face plate, since the spindle arm is movable from one handhole to another. A high-speed compressed air motor such as is used for operating Elliott Company's 2-in. tube cleaners drives the grinder. One half of a slip-on flexible coupling is fixed on the air motor spindle, the other half being fixed on the grinder spindle. A housing provides easy attachment or detachment of the motor, air hose, shut-off valve and motor lubricator.

The complete outfit for this handhole seat grinder includes two grinding wheels, three guide rollers for grinding gasket seats of different widths, a wire brush, stud adapters, plastic mounted viewing mirror, wrench, air hose and a motor lubricator. The entire kit weighs only 25 lb, packed in a convenient case complete with shoulder strap for carrying.

Magnetic-Type Oil Strainer

Winslow Engineering Company announces a new magnetic-type strainer which combines in one unit the bypass valves, pressure regulator, main control valve and the two strainer elements in which powerful magnets are located. A



quick-acting hand-operated three-way control valve permits the change of flow from one strainer element to the other, or through both elements. Adjacent to this three-way valve is a pressure regulating valve for adjustment of outgoing oil pressure.

The Model 200-MS-1 Winslow Duplex strainer body is of either cast bronze or iron. This model is designed to handle 15 gpm; a larger model to handle 40 gpm is also available. Where finer filtration of the lubricating oil is necessary, Winslow cartridge-type oil conditioners may be used in conjunction with the strainer.

Poly Phosphate Comparator

The Taylor Poly Phosphate Comparator, developed by W. A. Taylor & Company, claims to provide a simple, rapid and accurate method of analysis. Previous methods required several hours boiling to convert the glassy phosphates to the ortho form. By the Taylor method a complete determination requires only 20 minutes. After conversion, two reagents are added separately and the blue color formed is compared with the standards. This gives the total phosphate content. A determination on the cold sample (no boiling) gives the ortho present in the sample. The difference is the poly phosphate.

The outfit consists of a comparison block containing 8 standards, 0, 0.5, 1, 2, 4, 6, 8, 10 ppm, 2 comparison tubes, funnel filter paper, graduate, flask and reagents. All equipment is contained in a wooden carrying case $9^1/_4$ in. long, $6^1/_4$ in. wide and 9 in. high.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Aluminum Applications

Aluminum Company of America has issued a 76-page typescript book "Aluminum Applications by Industries" which lists approximately 3500 applications for this metal. The industries covered include Aircraft, Architecture, Automotive, Chemical, Dairy, Electrical, Food Processing Equipment, General, House Construction, Interior Furnishings, Marine Construction, Oil, Packaging, Precision Instruments, Railroads, Rubber, Sewage Disposal, Sports Goods, Structural and Textile.

Chemical Feed Systems

A 4-page folder (No. 451) has been issued by Milton Roy Pumps describing its "packaged" chemical feed systems for boiler water treatments. The bulletin explains why two distinct systems are recommended; for feeding sodium sulphite into feedwater lines and for feeding other chemicals directly into the boilers. It lists the various units by code number, by boiler pressure and by makeup water requirements, etc.

Insulating Brick

Harbison-Walker Refractories Company has issued a colorful 14-page bulletin featuring five brands of insulating brick for maximum temperature limits ranging from 1600 F to 2800 F. The bulletin discusses the application of H-W insulating brick in industrial furnace linings, illustrates a number of such furnaces and presents specific data on the thermal and other physical properties of the five brands illustrated.

Morganite

Morganite Brush Company has issued a 6-page folder featuring Morganite as a suitable material for liquid meter valves and slides. The basic ingredients of Morganite are natural graphite, petroleum cake, lamp black and retort carbon combined with pitches, tars and other binders. It is claimed to be strong, light in weight, self-lubricating, chemically inert and capable of withstanding high temperatures.

Reconversion Inventory

Allis-Chalmers has prepared three timely folders on How to Take a Reconversion Inventory of Your Centrifugal Pumps—V-Belt Drives—Electric Motors. Each folder outlines the required steps to be taken and provides as a guide a Check List to help in a quick appraisal of the condition of the equipment.

Bronze Bushings and Bars

Shook Bronze Corporation has issued a new 20-page catalog (No. 45) devoted to ready-to-use bushings and machined bronze bars made of a special alloy—Shook 664 Phosphor Bronze. This alloy is cast by a new method known as Radial Grain Control. Advantages claimed include increased resistance to crushing strain, greater load carrying capacity and improved non-seizing bearing surfaces.

Motor-Generator Maintenance Equipment

Ideal Commutator Dresser Company has issued a 36-page catalog entitled "Modern Motor-Generator Maintenance and Repair Equipment for Reconditioning War Weary Machinery." The book is generously illustrated, well indexed and includes Hints on Commutator Care—Troubles and Remedies.

Tube Cleaners

The Elliott Company has issued a new 4-page folder, Bulletin Y-19, on the Lagonda type 1300 series tube cleaner, emphasizing the improved lubrication system for these machines.

A cutaway view of the motor, an exploded view of its simple assembly and an illustration of its operation in curved tubes feature the inside spread of this new bulletin. A variety of models are illustrated on the back page, which also carries a reference list of motor numbers for tubes of various sizes.

Valves

The Wm. Powell Company has published a 20-page booklet "Powell Valves for Corrosion Resistance," which describes and illustrates its various types of valves which are available in a wide selection of pure metals and special alloys for corrosion service. The selection includes gate, globe and angle valves, "Y's," check, needle, relief, and flush bottom tank valves and liquid level gages.

Vent Sets

Buffalo Forge Company has issued a new 12-page bulletin (No. 3499 describing its line of motor-driven vent sets. The fans listed are designed for industrial and commercial ventilating work. Physical data, dimensions and ratings are given on "Limit-Load" belt-driven fans up to size 5, on cast iron "Baby" vent sets, on direct-connected "Limit-Load" fans up to size $4^1/_2$, and on "Shortboy" units in capacities up to 20,700 cfm.

BOOKS

1—Technologists' Stake in the Wagner Act

BY M. E. MCIVER, H. A. WAGNER AND M. P. MCGIRR

252 pages 6 × 9 Price $2.00

In view of an apparent increased interest in collective bargaining on the part of certain groups of technologists who, at the same time, are opposed to representation by labor unions, the authors, under the sponsorship of the American Association of Engineers, have attempted a full explanation of the Wagner Labor Relations Act and the rights of technologists under the Act.

Its administration by the National Labor Relations Board is discussed and various interpretations are cited. From these it would appear that the Board is invested with broad discretion in determining what constitutes employer domination in individual cases and in defining supervisory employees. Moreover, the functions of the Board are compared with those of the War Labor Board. The text is replete with questions and answers and a large number of decisions are cited.

2—Mathematics Dictionary (Revised Edition)

BY GLEN JAMES AND ROBERT C. JAMES

320 pages $6^1/_2 \times 9^1/_4$ Price $3.00

This invaluable reference book, which first appeared in 1942, is designed to provide a condensed source of facts and principles for men working in practical fields where mathematics is an essential feature. In this revised edition, many new terms have been added, more "working examples" have been introduced, irregular plurals added, typographical errors corrected. five-place logarithm tables have been substituted for four-place tables and extensive integral tables have also been added. Elementary concepts and definitions have been simplified for the benefit of the layman, but basic terms beyond calculus have been included so that the dictionary contains most of the terms which form the foundation of any advanced course in mathematics.

3—Chemical Engineering Thermodynamics

BY BERNETT F. DODGE

680 pages $5^5/_8 \times 8^3/_4$ Price $6.00

Mechanical engineers as well as chemical engineers should find this work a useful reference for attacking problems in thermodynamics that always arise from time to time. Here will be found means to save effort and time though some of the problems are possibly a little strange to the average mechanical engineer's customary field.

The book does not presuppose a wide knowledge of thermodynamics but approaches the subject by first defining and developing the essentials of the first two laws. This is followed in subsequent chapters by applying these laws to the operations and processes with which the engineer is concerned. The manner in which this has been accomplished will be found unusually simple and lucid, especially in the transition from one step to the next. The generous sprinkling of practical problems with their complete numerical step-by-step solutions will be thoroughly appreciated.

The book contains thirteen chapters: Definitions and Fundamental Concepts, The First Two Fundamental Laws, Quantitative Development of the Two Fundamental Laws and The Thermodynamic Functions, General Equations of Equilibrium, Pressure-Volume-Temperature Relations of Fluids, Thermodynamic Properties of Fluids, Compression and Expansion of Fluids, Thermodynamics of Fluid Flow, Heat Transfer, Refrigeration, Chemical Reaction Equilibrium, Vaporization and Condensation Equilibria, and Distillation Processes, together with an Appendix of useful constants and a broad Index of subjects and authors.

4—The Marine Power Plant

BY LAWRENCE B. CHAPMAN

402 pages Price $4.00

In the second edition of this excellent text, the student will find a short but direct and thorough introduction to the fundamentals of the selection and design of steam and diesel propulsion plants. The marine engineer will find it refreshing with many helpful guides to design procedure and computation and to revealing comparisons for the proper selection of equipment. Owners and operators will find it similarly useful, and in addition may utilize it to check the results and correct the operation of their vessels.

Fundamentals and thermodynamic principles are set forth in a manner easily comprehended and descriptions of marine equipment are handled with clarity. In the selection of equipment, the latest practices are brought out but sight has not been lost of installations of the recent past—of ships that will be in operation for some years to come.

There are chapters on Fuels, Marine Boilers, Combustion, Reciprocating Steam Engines, Geared Turbines, Turbo-electric Drive, Diesel Engines, Comparisons of Types of Propelling Machinery, Condensers and Their Auxiliaries, Power Plant Layouts and Computations for the Power Plants of Merchant Ships.

5—Plane Trigonometry Made Plain

BY ALBERT B. CARSON

389 pages $5^1/_2 \times 8^1/_4$ Price $2.75

This book deals with the fundamentals of plane trigonometry in greater detail than is done in most texts, and the discussions are presented in such a manner—accompanied by an unusually large number of figures and illustrative examples—that the student is enabled to comprehend how and why the principles are employed, and their practical application.

Beginning with definitions and principles of triangles, the subject is developed in eleven chapters to include inverse trigonometric functions and trigonometric equations. Most of the chapters conclude with pertinent questions and answers, a brief summary of the chapter and many practice problems. The remainder of the book is devoted to logarithmic and trigonometric tables and a very complete 5-page index.

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